International Journal of Pharmacy and Biological Sciences
ISSN: 2321-3272 (Print), ISSN: 2230-7605 (Online)
IJPBS | Volume 8 | Issue 2 | APR-JUN | 2018 | 316-329
Review Article | Biological Sciences | Open Access | MCI Approved| ज्ञान-विज्ञान विमुक्तये
|UGC Approved Journal |

SURGICAL SITE INFECTIONS (SSI)

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ABSTRACT

A post-operative wound infection or surgical site infection (SSI) is an infection of a wound from a surgery. Many micro-organisms live in and on our bodies and also in our environment. The bacteria may come from the skin, from the air, soil or water; or from the object used during the surgery. Likewise, it may be caused by complications from surgical hypothermia; contamination of the incision area by skin flora; surgical instrument contamination; and bacterial cross–contamination. Our bodies have natural defenses against the few germs that can cause harm. Our skin, for example, prevents germs from entering our bodies. A surgical wound infection occurs when germs enter the incision that the surgeon makes through patient's skin in order to carry out the operation. Most surgical wound infections are limited to the skin but can spread occasionally to deeper tissues. Infections are more likely to occur after surgery on parts of the body that harbour lots of germs. It may affect closed wounds or wounds left open to heal; superficial or deep tissues; and in severe cases, the internal organs. A surgical wound infection can develop at any time from two to three days after surgery until the wound has healed (usually two to three weeks after the operation). Very occasionally, an infection can occur several months after an operation. A wound infection is described as minor if there is discharge without cellulitis or deep tissue destruction, and major if the discharge of pus is associated with tissue breakdown. CDC (Centers for Disease Control and Prevention) provides guidelines and tools to the healthcare community to stop surgical site infections and resources to help the public understanding these infections and take measures to safeguard their own health when possible.

KEY WORDS

Surgical site Infections, Post-operative, Infection control

SURGICAL SITE INFECTION

A post-operative wound infection or surgical site infection (SSI) is an infection of a wound from a surgery. Many micro-organisms live in and on our bodies and also in our environment. The bacteria may come from the skin, from the air, soil or water; or from the object used during the surgery (Plowman, 2000) [(1)]. Likewise, it may be caused by complications from surgical hypothermia; contamination of the incision area by skin flora; surgical instrument contamination; and bacterial cross–contamination. Our bodies have natural defences against the few germs that can cause harm. Our skin, for example, prevents germs from entering our bodies. A surgical wound infection occurs when germs enter the incision that the surgeon makes through patient's skin in order to carry out the operation. Most surgical wound infections are limited to the skin but can spread occasionally to deeper tissues. Infections are more likely to occur after surgery on parts of the body that harbour lots of germs. It may affect closed wounds or wounds left open to heal; superficial or deep tissues; and in severe cases, the internal organs. A surgical wound infection can develop at any time from two to three days after surgery until the wound has healed (usually two to three weeks after the operation). Very occasionally, an infection can occur several months after an operation. A wound infection is described as minor if there is discharge without cellulitis or deep tissue destruction, and major if the discharge of pus is associated with tissue breakdown. CDC (Centers for Disease Control and Prevention) (Horan et al., 1992) [2] provides guidelines and tools to the healthcare community to stop surgical site infections and resources to help the public understanding these infections and take measures to safeguard their own health when possible (CDC, 2012) [3].

History of management of post-operative infection:

In the ancient times where history was recorded, there were tough laws governing surgery. In the code of Hammurabi, the Babylonian law provided that if a free person died from an operation, the surgeon's right hand was to be amputated, and in case the person was a slave then the surgeon was bound to repay the owner of the slave an equal value [4]. In 1809, McDowell performed a laparotomy on one Jane Todd Crawford in Kentucky, to remove a giant ovarian tumour before the introduction of antisepsis. His townsmen gathered around his house in large numbers with a rope slung over a tree ready for use, if the doctor should fail in the "butchery" they were convinced he was committing. They might well have hanged him had his patient died. There were other setbacks to major surgery in "hospitalism", the term coined by the 18th century surgeon who used it to describe post-surgical infection so commonly found in surgical wounds, Erysipelas, Pyaemia, Septicaemia and hospital gangrene [5,6].

In the mid-19th century, when surgical patients commonly developed complexity in form of postoperative "fever," followed by purulent discharge from their incisions, intensive sepsis and often death. In the late 1800s Joseph Lister, a British surgeon and pioneer of antiseptic surgery, introduced new principles of cleanliness which transformed surgical practice. This is popularly known as principles of antisepsis (Conte, 1994) [7] and it substantially reduced postoperative infectious morbidity. However, Erichsen, from University College Hospital in London was not convinced by this principle. Erichsen used the phrase 'hospitalism' for what we now call healthcare associated infection'. He provided 13 recommendations for its prevention - many of which remain valid to-day (Newsom, 2008) [8].

The incidence of postoperative infections decreased after 1941 and reached a low level until 1954. In the 1960s, before the correct use of antibiotics and the advent of modern preoperative and postoperative care, as much as one quarter of a surgical ward might have been occupied by patients with wound complications. As a result, wound management, in itself, became an important component of ward care and of medical education (Meakins, 2008) [9].

Following the introduction of antibiotics, early clinical trials in the 1950's reported either no benefit or a higher infection rate with antibiotic prophylaxis [10,11]. Moreover, the emergence of resistant strains was attributed, in part, to such use of antibiotics. Although a small number of authors supported the use of prophylactic antibiotics for "dirty" or contaminated cases most did not recommend their use in cleaner cases. Fortunately, studies by Burke in the early 1960's revealed the critical flaw in previous investigations and clinical failures [12]. Burke administered a single dose of penicillin systematically at various times before and after the inoculation of penicillin- sensitive staphylococcus aureus in the dermis of guinea pigs. Delaying the administration of antibiotics by as little as 3 hours resulted in lesions identical to those in animals not receiving antibiotics.

The field of hospital infection prevention gained momentum by the end of 1960's. The main focus was on the number and the nature of the micro-organisms contaminating wounds and the nature of human microbial flora in disease states. This led to major advancement in the use of prophylaxis and therapeutic antibiotics in surgical patients. From mid-1980's to mid-1990's, the focus was on procedure specific patient risk factors and how they influence the development of SSI. In recent studies, the emphasis has been placed on identifying host-related factors in high-risk surgical patients [13].

Sign and Symptoms of SSI

Postoperative infection often presents with nonspecific pain and swelling and can be difficult to diagnose accurately. Timely detection and accurate localization of infectious processes have important clinical implications and are critical to appropriate patient management.

Specific sign and symptoms of surgical site infection could be the following

- A wound that is painful, even though it does not look like it should be.
- High or low body temperature, low blood pressure, or a fast heartbeat.
- Increased discharge (blood or other fluid) or pus coming out of the

wound. The discharge or pus may have an odd colour or a bad smell.

- Increased swelling that goes past the wound area and does not go away

after five days. Swollen areas usually look red, feel painful, and feel warm when you touch them.

- Wounds that do not heal or get better with treatment.

Types of Surgical Site Infections

The CDC describes 3 types of surgical site infections:

1. Superficial incisional
2. Deep incisional
3. Organ/space

Immunity to infection

Innate (Non-Specific) Immunity

The elements of the innate (non-specific) immune system include anatomical barriers, secretory molecules and cellular components.

A. Anatomical barriers to infections [14]

1. Mechanical factors
2. Chemical factors
3. Biological factors

B. Humoral barriers to infection: [14]

1. Complement system
2. Coagulation system
3. Lactoferrin and transferrin.
4. Interferons
5. Lysozyme
6. Interleukin-1

C. Cellular barriers to infection [14,15]

1. Neutrophils
2. Macrophages
3. Natural killer (NK) and lymphokine activated killer (LAK) cells
4. Eosinophils

Rates of infection:

In various studies, the rate of infection has been found out based on different influencing factors. These factors include, Type of surgery, surgical classification, Area of surgery, length of operation, prophylaxis use of antibiotic and also some patient related risk factors like-age, Diabetes mellitus, Obesity, Smoking, Pre-existing Remote Body Site Infection etc. According to the NNIS (National Nosocomial Infections Surveillance by US Centers for Disease Control) system reports, SSIs are the third most commonly reported nosocomial infection, accounting for 14% to 16% of all nosocomial infections among hospitalized patients (Emori and Gaynes, 1993) [16].

Before the systematic use of prophylactic antibiotics infection rates were 1-2% or less for clean wounds, 6-9% for clean-contaminated wounds, 13-20% for contaminated wounds and about 40% for dirty wounds (Cruse and Foord, 1980) [17]. But now infection rates in National Nosocomial Infection Surveillance (NNIS) system hospitals were reported to be: clean 2.1%, clean-contaminated 3.3%, contaminated 6.4% and dirty 7.1%(Culver et al., 1991) [18]. So, since the introduction of routine prophylactic antibiotic use, infection rates in the most contaminated groups have reduced drastically. There is, however, considerable variation in each class according to the type of surgery being performed.

A research was carried out over a two-year period in Cumhuriyet University Medicine Faculty Hospital in Sivas, Turkey. Where, High infection rates were noted after colon resection (32·1%), gastric and oesophageal operations (21·1%), cholecystectomy (17·2%), and splenectomy (10·2%) and Low infection rates were noted after thyroidectomy, mastectomy, caesarean section and abdominal hysterectomy. (YalÃ§in et al., 1995) [19].

Sources of infection

Sources of infection are widely varied. Infections may be primarily acquired from a community or endogenous source such as that following a perforated peptic ulcer or secondarily from exogenous sources such as from the operating theatre with inadequate air filtration or the ward (e.g. poor hand washing compliance) or from contamination at or after surgery (such as an anastomotic leak). Wound infection is caused by exogenous or endogenous bacteria; infection is influenced not only by the source of the infecting inoculum but also by the bacterial characteristics (Meakins, 2008) [20].

Endogenic Sources.

Microorganisms may contain or produce toxins and other substances that increase their ability to invade a host, produce damage within the host, or survive on or in host tissue. For example, many gram-negative bacteria produce endotoxin, which stimulates cytokine production. In turn, cytokines can trigger the systemic inflammatory response syndrome that sometimes leads to multiple system organ failure. Certain strains of clostridia and streptococci produce potent exotoxins that disrupt cell membranes or alter cellular metabolism.

For most SSIs, the source of pathogens is the endogenous flora of the patient's skin, mucous membranes, or hollow viscera. When mucous membranes or skin is incised, the exposed tissues are at risk for contamination with endogenous flora. These organisms are usually aerobic gram-positive cocci (e.g., staphylococci), but may include fecal flora (e.g., anaerobic bacteria and gram-negative aerobes) when incisions are made near the perineum or groin.

When a gastrointestinal organ is opened during an operation and is the source of pathogens, gram-negative bacilli (e.g., E. coli), gram-positive organisms (e.g., enterococci), and sometimes anaerobes (e.g., Bacillus fragilis) are the typical SSI isolates.

Exogenic Sources

These SSIs pathogens include surgical personnel (especially members of the surgical team), the operating room environment (including air), and all tools, instruments, and materials brought to the sterile field during an operation. Exogenous flora are primarily aerobes, especially gram-positive organisms (e.g., staphylococci and streptococci).

Etiological agents:

Many different bacteria, viruses, fungi and parasites may cause wound infections. Infections may be caused by a microorganism acquired from another person in the hospital (cross-infection) or may be caused by the patient's own flora (endogenous infection). Some organisms may be acquired from an inanimate object or substances recently contaminated from another human source (environmental infection).

The skin is colonised by various types of bacteria, but up to 50% of these are Staphylococcus aureus (Eriksen et al., 1995) [21]. The most common postoperative superficial wound infection often presents with localised pain, redness and slight discharge, occurring within the first week, usually caused by skin staphylococci. According to data from the national nosocomial infection surveillance system, the distribution of pathogens isolated from SSIs has not changed markedly during the last decade where Staphylococcus aureus, Coagulase-negative Staphylococci (CoNS), Enterococcus spp. And Escherichia coli remain the most frequently isolated pathogens (Mangram et al., 1999) [22]. Furthermore, nosocomial blood stream infections are usually caused by Gram-positive organisms including Coagulase Negative Staphylococcus, S. aureus, Enterococci (Samuel et al., 2010) [23] (Chinnial, 2009) [24] and these microorganisms nearly always represent true bacteraemia such as E. coli and other members of the Enterobacteriacae, Pseudomonas aeruginosa, and Streptococcus pyogenes (Chinnial, 2009) [24].

In analyses of contamination rates after cholecystectomy, the main source of wound contamination was found to be the skin of the patient. So post-operative SSI can be most commonly occur due to S. aureus. However, a research conducted by YalÃ§in, A.N., et al (YalÃ§in et al., 1995) [19] showed slightly different output. According to their findings the commonest causative organisms in surgical wound infection are coagulase-negative staphylococci 21·7%, Staphylococcus aureus 19·7%, Escherichia coli 19·7%, Enterobacter spp. 17·6%, and Pseudomonas spp. 10·7%. Patients undergoing colorectal operations, the degree of contamination was assessed by the recovery of Enterobacteriacae spp. or Staphylococcus aureus in peritoneal irrigation fluid using dip-slides. Intraoperative contamination was strongly associated with postoperative infection (Claesson and Holmlund, 1988) [25].

Another study in Bangladesh in 1992, showed that E. coli was the major pathogen (60.0%) in the postoperative infection followed by S. aureus.

List of Risk Factors [22]

1. Age
2. Nutritional status
3. Diabetes
4. Smoking
5. Obesity
6. Coexistent infections at a remote body site
7. Colonization with microorganisms
8. Altered immune response

9. Length of preoperative stay
10. Operation Duration of surgical scrub
11. Skin antisepsis
12. Preoperative shaving
13. Preoperative skin prep
14. Duration of operation
15. Antimicrobial prophylaxis
16. Operating room ventilation
17. Inadequate sterilization of instruments
18. Foreign material in the surgical site
19. Surgical drains
20. Surgical technique
21. Poor haemostasis
22. Failure to obliterate dead space
23. Tissue trauma

The US Centres for Disease Control's (CDC) [(26)] NNIS (National Nosocomial Infections Surveillance) risk index is the method of risk adjustment most widely used internationally (Culver et al., 1991) [(18)]. Risk adjustment is based on three major risk factors:

1. The patient's state of health before surgery is reflected The American Society of Anaesthesiologists (ASA) score, reflecting
2. Wound class, reflecting the state of contamination of the wound
3. Duration of operation, reflecting technical aspects of the surgery.

Wound Class: [(27,28)]

Contamination of surgical wounds can be classified into one of four categories according to WHO clean, clean-contaminated, contaminated and dirty wound in which SSI's incidence is about 3%, 11%, 18% and 27% respectively. These categories depend on how contaminated or clean the wound is, the risk of infection, and where the wound is located on the body.

1. Clean Wounds
2. Clean contaminated wounds
3. Contaminated wounds
4. Dirty wounds

Diagnosis of SSI

Physical exam:

Caregivers will look closely at the wound, including the area around it. He will check for swelling, discharge, and how much tissue is infected. He will also look for other problems or signs of spreading infection.

Blood tests:

The blood may be taken from the patient's hand, arm, or IV to find out the present of microorganism in the blood.

Imaging tests:

Pictures of bones and tissues in the wound area may be taken using different imaging tests. Tests may include x-rays, magnetic resonance imaging (MRI), or bone scan. Caregivers use the pictures to look for broken bones, injuries, or foreign objects in the wound area.

Tissue biopsy and wound culture:

This is when a small piece of tissue is removed from wound. This sample is then sent to the microbiology lab for tests. The sample taken will also be checked to identify the organisms present in patient's wound. This helps caregivers learn what kind of infection the patient has and what medicine is best to treat it.

Treatment of SSI

There are many methods

1. Wound care:
2. Cleansing: This may be done by rinsing the wound with sterile (clean) water. It may be done using high pressure with a needle or catheter and a large syringe. Germ-killing solutions may also be used to clean your wound.
3. Debridement: This is done to clean and remove objects, dirt, or dead skin and tissues from the wound area. Caregivers may cut out the damaged areas in or around the wound. Wet bandages may be placed inside the wound and left to dry. Other wet or dry dressings may also be used. Caregivers may also drain the wound to clean out pus.
4. Wound cover: This may also be called a wound dressing. Dressings are used to protect the wound from further injury and infection. These may also help provide pressure to decrease swelling. Dressings may come in different forms. They may contain certain substances to help promote faster healing.
5. Medicines: Caregiver may give antibiotic medicine to fight infection. Patient may also be given medicine to decrease pain, swelling, or fever.
6. Hyperbaric oxygen therapy: This is also called HBO. HBO is used to get more oxygen into body. The oxygen is given under pressure to

help it get into the patient's tissues and blood. The patient may need to have this therapy more than once.

7. Negative pressure therapy: This is also called vacuum-assisted closure (VAC). A special foam dressing with an attached tube is placed inside the wound cavity and tightly covered. The tube is connected to a pump which will help suck out excess fluid and dirt from the wound. VAC may also help increase blood flow and decrease the number of bacteria in the wound.
8. Use of antibiotics: Appropriately administered antibiotic reduces the incidence of surgical wound infection. Antibiotics have two uses in surgery:

(1) To treat established infections.
(2) To prevent postoperative infection.

Management of antibiotic in the treatment of surgical infection covers a broad aspect. It is important to recognize the difference between Therapeutic, prophylactic and empiric therapy. Therapeutic antimicrobial therapy prescribed to clear infection by an organism or to clear an organism that is colonising a patient but is not causing infection. Prophylactic antibiotic should cover the most likely contaminating organisms and be present in the tissues when the initial incision is made and must be given 30-60 minutes before incision. The goal of prophylactic antibiotics is to reduce the incidence of postoperative wound infection. Empiric therapy is the continued use of antibiotics after the operative procedure based upon the intra-operative findings. Patients undergoing high infection rates should receive perioperative antibiotics.

However, treatment, rather than prophylaxis is required in case of pre-existing infection. So, timing of antibiotic administration is critical to efficacy.

Prophylactic antibiotics

Prophylactic antibiotics decrease the risk of infection and represents important components of most favourable management of the surgical patient. So, errors in antimicrobial prophylaxis for surgical patients remain one of the most frequent types of medication errors in hospitals. The antibiotics selected for prophylaxis must cover the expected pathogens responsible for infection, should achieve adequate tissue levels during operation, cause minimal side effects and be relatively inexpensive (WOODS and DELLINGER, 1998) [(29)].

A prophylactic antibiotic should be used where evidence of benefit exists. Choice of antibiotic depend on type of surgery, area of surgery, etiological agents mostly responsible for wound infections, patient's physical status and wound class. According to the Antibiotic prophylaxis in surgery (A national clinical guideline) Scottish Intercollegiate Guidelines Network, Prophylaxis antibiotics are highly recommended for Appendicectomy, Colorectal surgery, Caesarean section, Transurethral resection of the prostate, and Arthroplasty surgery to reduces major morbidity, hospital costs (SIGN, 2008) [(30)]. In gynaecology, for prophylaxis, first generation cephalosporin's are suitable choices to prevent postoperative sepsis, by E. coli, S. aureus and B. fragilis (Houang, 1994) [(31)].

Many systematic studies were carried out to measure the relative efficacy of antimicrobial prophylaxis for the prevention of postoperative wound infection in different surgery.

Selection of Antibiotic

Spectrum.

The antibiotic chosen should be active against the most likely pathogens. Single agent therapy is almost always effective except in colorectal operations, small bowel procedures with stasis, emergency abdominal operations in the presence of polymicrobial flora, and penetrating trauma; in such cases, a combination of antibiotics is usually used because anaerobic coverage is required.

Pharmacokinetics.

The half-life of the antibiotic selected must be long enough to maintain adequate tissue levels throughout the operation.

Administration Dosage, route, and timing.

A single preoperative dose that is of the same strength as a full therapeutic dose is adequate in most instances. The single dose should be given IV immediately before skin incision. Administration by the anaesthetist is most effective and efficient.

Duration

A second dose is warranted if the duration of the operation exceeds either 3 hours or twice the half-life of the antibiotic. No additional benefit has been demonstrated in continuing prophylaxis beyond the day of the operation, and mounting data suggest that the preoperative dose is sufficient. When massive haemorrhage has occurred (i.e., blood loss equal to or greater than blood volume), a second dose is warranted. Even in emergency or trauma cases, prolonged courses of antibiotics are not justified unless they are therapeutic. (Boxma et al., 1996) [32]

Efficacy of Prophylaxis Antibiotic

The combination of ciprofloxacin plus metronidazole as well as several ß-lactam based regimens are commonly used regimens for the treatment of patients with such infections.

A study, performed on 509 patients of abdominal surgery, evaluated the efficiency of co-amoxiclav compared with cefuroxime plus metronidazole for the prevention of postoperative wound infections. In the study, 230 patients were given co-amoxiclav with and this came up with a total wound infection rate of 5.6%. Additionally, 225 patients were given cefuroxime plus metronidazole and that resulted in a total wound infection rate of 3%. It is noteworthy that the difference between infection rates was not significant (Palmer et al., 1994) [33].

In a Prospective study on 580 patients undergoing arterial surgery involving the groins was done to evaluate the efficacy of oral ciprofloxacin compare with IV cefuroxime as a prophylaxis. The patients were divided into two groups, and on the day of surgery one group was given ciprofloxacin 750 mg × 2 p.o. and the other one taken cefuroxime 1.5 g × 3 i.v. The wound infection rate in the ciprofloxacin group was 9.2% (27 patients) and in the cefuroxime group 9.1% (26 patients). The infection rate was similar in the two groups. Thus, oral administration of ciprofloxacin is an attractive, cost-effective and safe alternative to prophylaxis in vascular patients capable of taking oral medication on the day of surgery (Risberg et al., 1995) [34].

PREVENTION OF SURGICAL SITE INFECTIONS (SSI)

Protection of surgical patients from infection is a primary consideration throughout the preoperative, operative and postoperative phases of care. Bacterial infection of surgical incisions may have results that range from inconvenience to disaster, from small stitch abscess to massive tissue necrosis, septicaemia and even death. Some of the factors that determine surgical site infection and its consequences are beyond the control of surgeons. But others can be controlled. The preventive measures against surgical site infection are described below.

Aseptic measures in operation theatre:

Operation theatre complex: It should be scientifically planned, including barrier system, located away from the inpatient area and located on the top floor. Operation theatre complex should be consisting of four zones: outer zone, restricted/ clean zone, aseptic zone and disposal zone. Outer zone is the area for receiving patients, messengers, toilets and administrative function. Restricted zone/ clean zone consists of changing room, patient transfer area, stores room, nursing staff room, anaesthetist room, and recovery room. Aseptic zone consists of scrub area, preparation room, operation theatre and area for instrument packing and sterilization. Disposal zone is the area where used equipment is cleaned and biohazardous waste is disposed.

Criteria of an ideal operation room:

It should be big enough for free circulation, having two openings towards scrub area and towards sterile area, openings fitted with swing door, well ventilated, air conditioned by-

High efficacy positive pressure air filter system. As per US Public Health services minimum requirement for opera-ting room air are 25 changes per hour, positive pressure compared with

corridors, temperature between 18 and 24” C and humidity of 50 to 55%. Operation table to be kept away from the entrance and head end should be close to the sterile area

(Modi 2010) [35].

Cleaning and disinfection of operating room:

Cleaning, disinfection and sterilization are the cornerstones in ensuring operation room asepsis. Cleaning is a form of decontamination which removes organic matter and visible soils that interfere with the action of disinfectant, reduces the bacterial count and can be done by scrubbing with detergents and rinsing with water. For disinfection Phenol (Carbolic acid 2%) is used, to wash floor every day after surgery, mop operating room walls, tables, mats, instrument trolleys, stools followed by a wipe done with 70% alcohol (Modi 2010) [35].

Formaldehyde fumigation:

This procedure is commonly used to sterilize the operating room (OR). Fumigation is advised at weekly intervals. For an area of 1000 cubic feet 500 ml of 40%

formaldehyde in one litre of water, stove or hot plate for heating formalin and 300 ml of 10% Ammonia are required.

Procedure: Close all doors & windows air tight and switch off fans and A.C. Heat formalin solution till boiling. Leave the OT unentered overnight. Enter the OT next day morning with 300ml of ammonia. Keep the ammonia solution for 2-3 hrs to neutralize formalin vapours then open the OT to start surgery (Modi 2010) [35].

Ultra violet radiation:

Daily U.V. irradiation for 12 -16 hours is a useful procedure. It is to be switched off 2 hours before surgery (Modi 2010) [35].

Hand Washing Procedure:

Remove watch and other jewellery. Turn on the tap using the elbow and wet hands and forearm from finger tips to elbows, so that water runs down from fingers to elbow. Apply soap and scrub each hand with the other. Use rotatory movements from fingertips to elbows with special attention to the nails and the webs of fingers. Rinse thoroughly under running water in the same manner as above. Scrub with soap and water for 7-8 minutes. With povidone iodine or chlorhexidine solution, scrubbing twice for 1- 2 minutes each is adequate. Close tap with elbow taking care not to touch any spot that has been scrubbed. Dry with a sterile towel, begin with hands and proceed to wrist and forearm. Iodophor or an alcohol is applied following the surgical scrub. Approximately 35 ml of alcohol for 5 minutes is rubbed until the hands are dry. The proper method of wearing sterile gown and gloves to be followed. After wearing sterile gloves wash hands with balanced Salt solution or Ringers lactate to remove talc from the gloves (Modi 2010) [35].

Asepsis and Antisepsis

The term asepsis describes methods for preventing contamination of wounds and other sites by ensuring that only sterile objects and fluids come into contact with them; the risks of airborne contamination are minimized. Antisepsis is the use of solutions, such as chlorhexidine, iodine or alcohol, for disinfection (Kirk and Ribbans 2004) [36].

Theatre clothing

1. Gowns
2. Mask
3. Eye protection/visors
4. Tie up long hair
5. Foot wear
6. Gloves

Surgeon preparation

1. In order to minimize the risk of transmitting infection to patients, a surgeon must all satisfy local occupational health requirements before entering the operating theatre. For example, a surgeon must not operate with bacterial pharyngitis, during the prodromal period of a viral illness or with chronic or infected skin conditions. Surgeon should try to avoid operating if he/she has cuts, cracks, sores or rashes on his/her hands or forearms.
2. The term 'scrubbing up' is unlikely to disappear from surgical practice but repeated scrubbing is counterproductive because it results in skin abrasions and more bacteria being brought to the surface. At the start of a list a surgeon should have an initial scrub of 3-5 minutes; thereafter, effective hand-washing with an antiseptic between cases is sufficient. Sterile, single-use brushes of polypropylene should be used. Shower prior to operating should not be practiced, as it increases the number of bacteria shed from the skin (Kirk and Ribbans 2004) [36].
3. Antiseptics commonly used for hand washing are 4% Chlorhexidine gluconate (Hibiscrub), Hexachlorophane (pHisoHex) or Povidone-iodine (Betadine).
4. Surgeons hands should be dried thoroughly using single-use sterile towels. Hot-air drying machines are not recommended (Kirk and Ribbans 2004) [36].

Preparation of the patient

1. The longer a patient stays in hospital before operation, the greater the likelihood of a subsequent wound infection. Hospital stay should be as short as possible. The patient should be socially clean prior to operation. Infections at other sites increase the risk of surgical wound infection; therefore, diagnose and treat pre-existing infections before elective operation. Similarly, consider eradicating MRSA carriage in colonized patients prior to elective surgery.

2. The patient can be transported to theatre in bed directly, after being changed into a clean operating gown. Remove ward blankets before entering theatre. Trolleys must be cleaned daily.

3. Shaving of the operation site increases wound infection rates because of injury to the skin. If hair

removal is necessary, clippers or depilatory cream can be used. If it is essential to shave the area, it should be performed as near as possible to the time of operation, preferably by the surgeon, prior to scrubbing up.

4. The skin area around and including the operation site should be prepared, first, with detergent for cleaning and degreasing, then with antiseptic solutions. For intact skin consider alcoholic solutions of chlorhexidine or povidone-iodine rather than aqueous solutions. Care should be taken regarding fire hazard when applying alcohol solutions and using diathermy. For vaginal or perineal disinfection consider a solution of chlorhexidine and cetrimide (Savlon).

5. Traditionally the periphery of the proposed incision site was protected with sterile cotton drapes; however, these soon become wet, diminishing their protective properties. Incisional plastic drapes have been advocated but Cruse & Frood in 1980 showed that applying adhesive plastic drapes to the operation area does not decrease the wound infection rate; this has since been confirmed in a study of caesarean section (Kirk and Ribbans 2004) [36].

Cleaning and disinfection of instruments

Decontamination, or the process of removing microbial contaminants, can be carried out by cleaning, disinfection or sterilization.

Cleaning: It is a process that removes visible contamination but does not necessarily destroy microorganisms. It is a necessary prerequisite to effective disinfection or sterilization (Kirk and Ribbans 2004) [36].

Disinfection: It is a process that reduces the number of viable micro-organisms to an acceptable level but may not inactivate some viruses, hardy organisms such as mycobacteria and bacterial spores (Kirk and Ribbans 2004) [36].

1. Antiseptic: A topical disinfectant that may safely be applied to epithelial tissues is known as an antiseptic. Antiseptics include chlorhexidine, iodophors such as povidone iodine and 70% alcohol (Kirk and Ribbans 2004) [36].

2. Disinfection by moist heat: Disinfection of heat-tolerant items can be achieved reliably by exposure to moist heat; for items, such as surgical equipment and bedpans it can be carried out using a washer-disinfector. Recommended time-temperature combinations are 71 C for 3 min, 80C for 1 min or 90C for 12 s. Boiling water kills bacteria, some viruses including human immunodeficiency virus (HIV) and hepatitis B virus (HBV) and some spores. It does not sterilize. Soft water at 100C at normal pressure for 10 min is satisfactory. Suitable instruments include specula, proctoscopies and sigmoidoscopies (Kirk and Ribbans 2004) [36].

3. Chemical disinfection: It can be used where heat cannot. A good example is the use of glutaraldehyde 2% (Cidex). It is suitable for instruments that cannot be autoclaved, sharp cutting instruments, plastic and rubber items and endoscopes. It is effective against vegetative pathogens in 15 minutes and resistant pathogenic spores in 3 hrs. It is toxic, irritant and allergenic.

Caution: Instruments sterilized by this method should be thoroughly rinsed serially 2 to 3 times in trays filled with sterile water. Other chemical disinfectants include hypochlorite solutions, chlorine dioxide, super oxidized water and peracetic acid (Kirk and Ribbans 2004) [36].

Sterilization of instruments

Definition: Sterilization is defined as the complete destruction of all viable microorganisms, including spores, viruses and mycobacteria (Kirk and Ribbans 2004) [36].

1. Autoclaving:

Steam under pressure attains a higher temperature than boiling water and the final temperature is directly related to the pressure. Instruments can be reliably sterilized by steam under pressure using autoclaves. The process can kill bacteria, including Mycobacterium tuberculosis, viruses and heat-resistant spores. Autoclaving at 121*C for 20 minutes at 15 lbs per square inch pressure effectively kills most micro-organisms and spores (Modi 2010) [35]. The preferred cycle is 134*C at 2 atmospheres for a holding time of 3 min, which entails a total cycle time of at least 30 min to reach the required temperature. Autoclaves should be centralized in specialized units, e.g. the sterile service department (SSD). Autoclaving is suitable for sterilizing metallic instruments, except sharp knives and fine scissors.

2. Dry heat:

Sterilization can be achieved by dry heat at 160C for a holding time of 1 h. The process is inefficient compared with steam sterilization but has the advantage of being able to treat non-aqueous liquids, ointments and airtight containers. It is also useful for avoidingcorrosion of non-stainless metals and instruments with fine cutting edges, such as ophthalmic instruments. Do not use it for aqueous fluids or for materials that are likely to be damaged by the process, such as rubber and plastics. This equipment is subject to rigorous checks and maintenance.

3. Sterilant:

These are chemical compounds that, under defined conditions, are able to kill bacterial spores (Kirk and Ribbans 2004) [36].

a. Ethylene oxide (ETO): It is a highly penetrative, noncorrosive agent with a broad cidal action against bacteria, spores and viruses. It is also flammable, toxic, irritant, mutagenic and potentially carcinogenic, and should not be used when heat sterilization is possible. Its main uses are for wrapped and unwrapped heat-sensitive equipment. It is ideal for electrical equipment, flexible fibre endoscopes and photographic equipment. It should not be used for ventilatory equipment. EO sterilization is a mainly industrial process for single-use medical devices (Kirk and Ribbans 2004) [36].

b. Glutaraldehyde: Shorter immersion times provide disinfection, but 3-10 h of exposure to 2% alkaline glutaraldehyde is required for sporicidal activity (Kirk and Ribbans 2004) [36].

c. Other sterilant: include peracetic acid, superoxidized water, gas plasma and chlorine dioxide; however, validation processes have not yet been established by the Department of Health for some of these newer technologies (Kirk and Ribbans 2004) [36].

4. Irradiation (gamma rays):

This is a cold sterilization method with high penetrating power and lethal to DNA (Modi 2010) [45]. It is an industrial process suitable for sterilizing large batches of similar products, such as catheters and syringes (Kirk and Ribbans 2004) [36]. It is most useful for disposable and rubber items as well as ringer lactate (Modi 2010) [35].

Spillages

Body fluid spillage should be removed as soon as possible. Gloves and a plastic apron should be worn. First, cover spills with an appropriate disinfectant, then absorbent paper towels. Discard as clinical waste (Kirk and Ribbans 2004) [36].

Waste disposal

Hospital waste should be sorted to ensure it is correctly disposed of. 'SHARPS' must be placed in approved containers, and clinical waste in yellow plastic bags. These are disposed of, usually by incineration, separately from domestic waste, which may be sent for landfill. Other categories of waste requiring segregation include pharmaceuticals and radioactive or cytotoxic waste (Kirk and Ribbans 2004) [36].

Prophylactic Antimicrobial

Although there are various ways of preventing SSIs, the most appropriate way is administering antibiotic prophylaxis at the appropriate time, (20 min before surgery). Example is Zinacef 1,5g or 3g according to the surgeons' instructions. The administering of antimicrobial prophylaxis before surgery has been proved to decrease greatly the incidence of postoperative infection particularly where the inoculums of bacteria is high, such as vaginal surgery or where there is insertion of an artificial device, for example hip prosthesis. Appropriate timing of administering antibiotics to prevent surgical infections is critical but ignored. Surgical site infections may be prevented by controlling the risk factors in cases of scheduled surgery (Michael Andrea, Jose, Wendon & Ginsburg) [37].

According to Beaver, (2008) [58] antibiotic cycling can prevent hospital- acquired MRSA; it also decreases development of antibiotic resistance strains of gram-negative organisms. The benefits of antibiotic cycling appear to reduce the "monotonous exposure" to one agent over time and reduce the selection pressures for any single agent.

Asepsis:

Rigorous adherence to the principle of asepsis by all scrub personnel is the foundation of SSI prevention. Anaesthesia personnel also should abide to these principles; there have been cases where the anaesthesia personnel were implicated as the source of the pathogens. Lack of adherence to the principles of asepsis during the anaesthesia procedure has been associated with outbreak of post-operative infections (Mangram et al. 1999) [22].

Skin and Hand Hygiene:

When it comes to preventing SSI, skin antisepsis is the cheapest and most simple way to reduce SSI, but very important. The surgical team take skin preparation very seriously because it plays a bigger role in SSI prevention. The outer layer of the skin (corneal) protects the skin from bacteria and foreign particles. Corneal cells are surrounded by lipid platform which consists of ceramides, cholesterol and free fatty acids. The lipid platform plays the role of destroying some microbes. Repeated wash removes lipids from the corneal therefore weakens the protection towards microbes.

There are approximately 100-1000 microbes on the skin and are mostly situated on corneal layer, if the hands are not disinfected properly after patient contact, the microbes will be transferred to the next patient (Markkanen & Huhtala 2006) [38].

Hypothermia:

Patient warming is another issue healthcare professional generally agree is a factor in SSI occurrence, but sometimes disagrees on the extent and the solutions. According to Beaver (2008) [58] lack of proper warming may result to postoperative complications such as shivering, wound infection, and cardiovascular problems, plus metabolism of drugs is prolonged. "All of these complications can contribute to prolonged postoperative recovery," she adds. It's important to maintain the patients' temperature during intraoperative period to prevent complications resulting from hypothermia. She believes that not enough attention is paid to the preoperative use of warming devices, and that this leads to intraoperative "catch-up" to achieve normal temperature. There may be a direct correlation between the use of preoperative warming devices and SSI. Patients' temperature plays a great role to the immune system and therefore a key factor in prevention of wound infection. She believes that if all patients are kept in the normal temperature throughout, the number of patients who develop SSIs will decrease. She also suggested that every hospital should develop protocols to make sure patients complete their operation and goes to the recovery area in a normothermic state (Beaver, 2008) [39].

Paulikas, (2008) [40] states that, most common complications arise when normothermic is not maintained. Perioperative nurses should understand the importance of maintaining normothermia, the causes of hypothermia and the adverse patients result from hypothermia. Nursing interventions to help prevent hypothermia can be implemented during each phase of perioperative care. [41]

Impact of SSI

Infection is an important cause of morbidity in postoperative patients even though surgical procedure and antibiotic therapy keep on improving. Surgical site infections have many adverse effects on patient's health and economy. Surgical site infections (SSIs) result in up to $10 billion in costs every year.

Compared to an uninfected patient, the patient with an SSI:

- Stays hospitalized 7 days longer;
- Is 60% more likely to spend time in the ICU;
- Is 5 times more likely to be readmitted within 30 days of discharge;
- Is twice as likely to die (Perencevich et al., 2003) [42]

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