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AN OVERVIEW OF FACTORS INFLUENCING THE OCCURRENCE OF POST-OPERATIVE WOUND INFECTION

Pramila M.[1], Prabhusaran N.[2*], Karthik P.[3], Lalithambigai J.[2], Meenakshisundaram M.[1], and Ganesh Kumar A.[4]

[1]Department of Biotechnology, Nehru Memorial College, Tiruchirapalli, India.
[2]Department of Microbiology, Chennai Medical College Hospital and Research Centre (SRM Group), Tiruchirapalli, India, (Affiliated to The Tamilnadu Dr. M.G.R. Medical University, Chennai).
[3]Department of Surgery, Chennai Medical College Hospital and Research Centre (SRM Group), Tiruchirapalli, India, (Affiliated to the Tamilnadu Dr. M.G.R. Medical University, Chennai).
[4]Department of Marine Sciences, Bharathidasan University, Tiruchirapalli, India.

***Corresponding Author: Dr. Prabhusaran N.**
Department of Microbiology, Chennai Medical College Hospital and Research Centre (SRM Group), Tiruchirapalli, India, (Affiliated to The Tamilnadu Dr. M.G.R. Medical University, Chennai).

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ABSTRACT

Microbial infections and sepsis are observed as the significant problem in modern surgery. Various factors that are influencing surgical site and other wound infections are studied. The association of surgical procedures with burden of infections increases the morbidity, mortality and cost of the health services. The awareness among health care professionals related to the multitude of surgical risk factors that leads to various aerobic and anaerobic infections will support the promotion of effective preventive strategies. The influence of type of suture material used with infection rate and coincidental use of steroids in the high doses employed in surgical practice. A strong association between the individual surgeon and the development of a wound infection was demonstrated and this supports the need for routine surgical audit. This review is providing the detailed information regarding the factors that influencing the occurrences and incidences of post operative wound infections in health care settings.

KEYWORDS: Post operative wound infections, factors, associations.

INTRODUCTION

Human body was protected from the infection by skin which was gives a first line defense. Destruction of tissue through the skin will lead to wound formation[1] and it gives a space for the accumulation of the microbial population into the internal tissue which leads to infection.[2] The infected tissue was devitalized therefore the host immune response is not respond for the wound infection thus may leads to the condition on worse which means the microbial population was getting higher in this state.[3]

Wound and wound infection

Wound infection occurs due to the dead tissue and poor blood supply in the wound allows the aerobic and anaerobic bacteria microbes to colonize into the tissue.[4] Many of those microbes heal the wound successfully but in some cases most microbes proliferate and damage the tissue that may delay the healing. On this stage it may have a chance to cause severe from illness to death. A microbe present in the wound is progressed by following systemic process that is contamination, colonization, infection. Infection also happened in three manners-localized infection, spreading infection and systemic infection.[5]

Stages of wound infections

The stages of this wound infection continues the population and virulence of the microbes increase continuously incorporation with the host. In some cases, wound infection is highly severe, cause cellulitis or metastatic spread to the spine or other distant sites.[6] Acute wound was expected when a patient meet a cutaneous injury that was heal within an appropriate time duration, those are need treatment to heal the wound depend upon the site, type and depth of wound. For surgical patients they are require medications to avoid wound healing but for traumatic injury patients they are all need antimicrobial therapy for their wound healing process because on they have a chance to get various kind of microbial population accumulation and non-viable foreign materials wound occurs.[3]

Wound Healing – an overview

Most of wounds heal by host immune system within a week. But sometimes the contribution of microbial flora population and other endogenous factors also play a vital

role in delaying the wound healing. The unfavorable pathophysiological conditions also a special concern in delaying of wound healing which includes dead cell around the tissue in wound, inappropriate perfusion in the local tissue at the damaged site and inflammatory activity.[7] In wound care, clinicians have efficient treatment to treat and heal the wound in a successive manner. They may use several new products and improved techniques in a controlled manner.[8] Healing of wound is a complex process, it requires actual environment done by the technology advancement. Nearly, 3000 products has been originated and used to treat wound healing according to the type and the nature of wound. Each product works in a specific way depend upon their type of wound.[9]

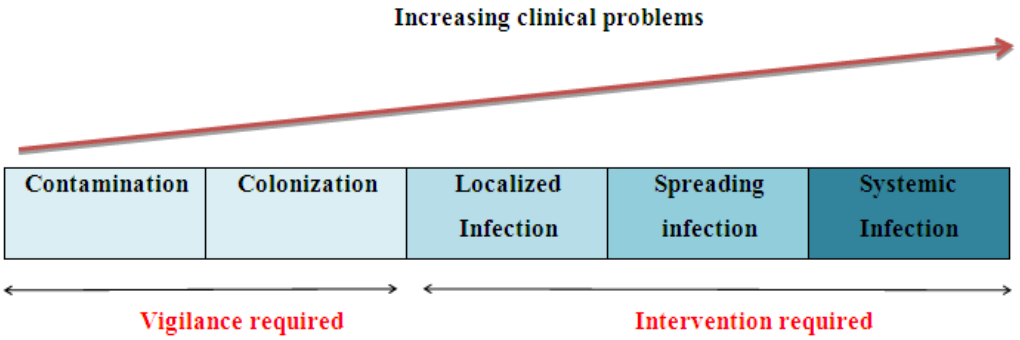

Figure 1: Requirement of vigilance and interventions to reducing post surgical complications.[5]

Pre-operative infections

Post-operative wound infection is a major concern in the patients who are all met the surgery process than the out patients. The infection caused by the exogenous environment or surrounding and the endogenous micro flora population are playing a vital role. Even though several pre-operative measures identify those are also responsible for the post wound infection. Regarding this various precaution too carry out in the pre surgery procedures that was highly reducing the incidence of post-operative wound infection.[10] Using an appropriate procedure the wound and infection was treated within 30 days, thus decrease the patient's morbidity and mortality.

Minimizing the surgical wound healing is not an easy thing, which encompasses several complicated parameters including precise operative techniques, administration of proper antibiotics, preventing measures to neutralize the bacterial population present at the site of infection, cleanliness of the operative room and endogenous skin flora of the patients.[11] In the chronic wound the diagnosis of wound infection is highly crucial part, in case the inappropriate diagnosis was done means it may lead severe side effects to the patients because of the antibiotic selection, administration and treatment. But delaying diagnosis also lead to severe the infection, so proper diagnosis within a short time is a beneficial method to treat the infection in a quick and effective way. Thus helps to treat and heal the infection in wound quickly.[12]

Surgery and surgical interventions

Surgery is a medical specialty that uses operative manual and instrumental techniques on a patient to investigate or treat a pathological condition such as injury or disease, to help to improve body functions or physical appearance. Some surgeries may relieve or prevent pain and others it may reduce or quit the symptoms of the disease. Nowadays, some surgeries are done with lasers and some needed large or small incisions such as elective surgery, emergency surgery, amputation, excision, exploratory surgery, gamma knife radio surgery, large surgery, micro surgery, minimally invasive surgery, reconstructive surgery, re-plantation surgery, robotic surgery and transplant surgery. More than 150 years ago, before the invention of anesthesia the patients are advised to surgery is a too rare things, because the rate of cure was low and the death ratio high.[13]

Over the past decade there are more than 200 million surgeries happen over national and global level which maintains the surgery rate constantly. Because of some extent reasons the surgery rate was constant that is late diagnosis of disease diagnosis or without diagnosis, treatment delayed or absence to treat the disease, no more discussion or communication among the clinical experts. In this case, surgeons must know about the patient's case details and severity, fix the diagnosis and treatment process, finally they should take the decision in a very quick manner, thus may reduce the death rate of the patients in worldwide.[14] Patients are advised to undergo surgery in some specific cases, not for everyone.[15]

For cancer treatment, surgery is a best option which gives a best modality to the patient especially solid tumor treatment. In this case, age determination is not a matter; elder patient gives a best output after surgery equal to the young age patients. Age is not an issue in some kind of surgery as well as treatment options.[16] Probably we may get this much of advancement in medical field, some lacking things was also available those are, lack of medical knowledge between rural peoples, inadequacy of transport, condition of weather, poor infrastructures of rural hospitals, treatment cost and depletion of medical clinicians in hospitals. In some cases, patients have

knowledge about conventional remedy or medicine for appropriate infections or diseases because they have a local consultant and also they may afraid about the cost and queues at hospitals.

Some peoples are generally having a fear about surgery; these are the reasons Among young age adults, of patient whenever we may improve our medical needs. Any one of the above said reason may be responsible for 10-20% of adult's death and 15% of the maternal death per year was recorded.[17] Still airway trauma is highly lethal, but after surgery expects a good outcome. This was happen because of early diagnosis of disease by well understanding about infection state, quick diagnosis and treatment which help to maintain vocal cord function properly, sustain the airway rectitude and reduces the loss of pulmonary parenchyma.[18]

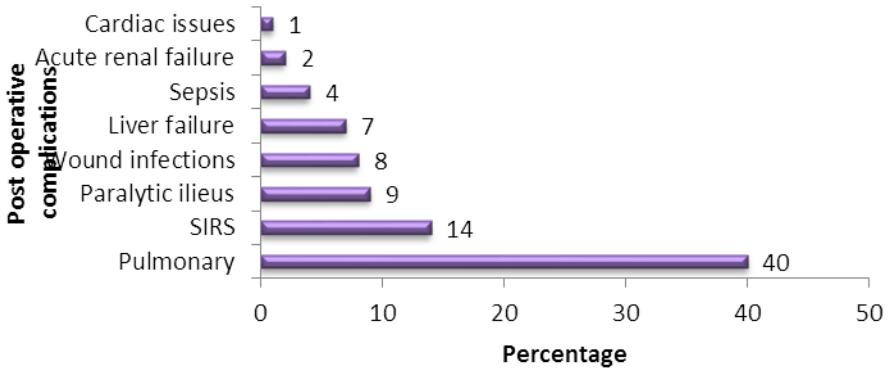

Figure 2: Post operative complications.

In patient have severe complications when the trauma affect extremely leads to acute peripheral nerve injuries which also present in 3-10% of patients depend upon their trauma mechanism. Among young age adults trauma affect the physically due to trauma injuries and in some cases nerve injuries recover immediately when patient undergo surgery which is the best option in traumatic nerve injury. The following conditions are the indications for surgery in peripheral nerve injury - mechanism, severity of lesion, level of neuropathic pain, clinical examination findings and time duration between injury and treatment. Because of gunshot the nerve injury happen means, the wound consider as a close injury instead there is no tissue exposure.

Due to indirect heat and shock created by the bullet, create lesions, therefore the surgery is not necessary immediately but surgery was performed 3-4 months later. The physical disability due to peripheral nerve injury was reconstructed by suitable improved microsurgical technique.[19] In most cases surgical interventions cause infection among patients after surgery. James et.al reported that the prolonged extracorporeal of heparinized neonate is a major surgical intervention in infants. Repetitive surgery increase the rate of mortality whether postponed the surgery until recover from respiratory surgery contribute a best outcome over the surgical intervention. Blood loss severity should be in control whenever goes with these algorithm.[20] The great sensitive and specific problem is short cervix and preterm birth in the mid trimester is a major risk factor, still researchers try to reduce the preterm birth.[21]

Surgical intervention in Rheumatoid arthritis is creating a major issue, but it makes mild, swollen and tender joints and the rate of joint anthroplasties when the Rheumatoid arthritis related replacements.[22] Emergence of multidrug resistance is again increase the incidence of Tuberculosis (TB) which is resistant against isoniazid and rifampicin antibiotics. Still TB is not controlled by therapy alone, it require surgery. In some cases patients suffer severe progressive disease and infected microbes also resistant those are not under complete therapy, this leads to surgical intervention proposed to treat the infection.[23]

Sterilization of ICU

A heterogeneous infection was caused by contaminated operation theater, thus the quality of operation is a most important thing in nowadays.[24] Surgical site infection caused by various factors, the most concentrated thing is patient related and procedure related infections. Most important thing is the surgical infection is influenced by quality of operating theater. Operating theater must be in a sterilized condition, because the environments contain several macro and micro pollutants which induce the rate of infection among patients. The quality of the operating theater is achieved by proper procedural cleaning, maintenance and giving proper training to the staff.

Aseptic method is a specific practice performed carefully in the area around the operation theater to decrease the infection during and after surgery.[25] In the operation theater microbial load vary depend upon the zones, that was managed by a decreasing of positive pressure ventilation gradient. The architecture of the operating theater arranged in various level of zone, each zone consists of several things and parameters to using the zone too. In the protective zone, it include all the equipments for all medical and paramedical uses, clean zone contains store room for equipments, service room for staffs, aseptic zone includes operation room in a

sterilized condition and disposal zone comprise area for disposing.

Basic care of operation theater includes ventilation, cleaning and chemical disinfectants.[26] Guidelines for using and maintenance of operating theater is regulated by several international scientific societies thus contain room contain air conditioning with HEPA filters, positive pressure and exchange of the circulated air per hour which is highly reduce the incidence of surgical infection after surgery.[25]

Surgical infection- Indian Scenario

According to the 9th edition of the International Classification of Diseases (ICD-9) criteria, an international benchmarking about the surgical procedure to avoid surgical site infections is clearly mentioned and defined. Ignoring the surgical site infection is not a good thing, because it leads to severe pain, swelling, delayed wound healing, increase the use of antibiotics, increase the resistance nature of the pathogens etc. In India among people they are not that much aware about the post-surgical infection and its effects thus will increase the incidence of surgical infection.

In 2012 World Bank's release the gross income range list, thus conclude 68% of the world countries coming under low income economy thus limited the surgical site infection and its surveillance programs among peoples.[27] Poor medical infrastructure and continuous use of antibiotics is increase the risk of surgical site infection in India. Over all, Surgical Site Infection (SSI) and Catheter Related Blood Stream Infection (CRBSI) is the predominant type of Hospital Acquired Infection (HAI), new implementation and preventive measure is the major conclusion to overcome this problem in India.[28] Post-operative stay increase the chance of surgical site infections, highly occur in emergency surgery patients than the elective surgery patients and the risk factor for the SSI is obesity, diabetes and anemia.[29]

Surgical Site Infections (SSIs)

Patients who are all underwent surgery; they are basically express low immune resistance. Among the hospital infection, surgical site infection is third category, the infection cause the patients who are all stay more than 12 days in hospital. Various factors that are influencing the surgical site infection are patients age and obesity, type of disease, etc. Environmental and sanitary factors cause the high rate of incidence of infection.[30] Diagnosis, therapeutic resources and the use health care is reducing the risk of infection. Counseling, dietary plan, personal hygiene and exercise is highly worth among patients who are all attain surgery. Patients also must be aware and understand about their surgery, possibility of infection which improve their health in a well manner.[31] The threatening thing after surgery to the patient is SSI, immune response of the patient getting very low.

Universally, 2-5% of surgical patients develop post-surgical infection and it contribute surgery related mortality and morbidity.[32] Every country have some parameters to operate a surgery so the regulation vary from each hospital to hospital, a report shows 77% of the death record only because of surgical site infections.[33] Specific identification and rate of the infection is important whenever patient acquire post-surgical infections which are the currently available infection preventive options.[34] Hospital acquired infection may originate from the patients normal flora that may be derived from the hospital environment. Among those infectious pathogens, Multidrug Resistant *Staphylococcus aureus* (MRSA) is commonly available in the hospital environment so this may be first microbes to create the infection.

In this state, the change of antibiotics for specific infective pathogens, reduce the risk of surgical site infection.[35] The causative may be aerobic or anaerobic that enters the wound during the surgery. The lowest rate of infection range is 2% which is followed by clean operations, the source of contamination from exogenous microbes.[36] Surgical Site Infections is more in dirty wounds when compared to the contaminated or clean wounds but the reason for the contamination is vary depend upon the type and site of wound.[29]

Bacteremia

The most serious infection among the surgical and hospital acquired infection is Blood stream infection (BSI), this condition make a serious illness to patients when compare to the primary infections caused after surgery. The evaluation of the blood stream infection is still not evaluated.[37] Detection of microbial load in the blood stream is defined as Bacteremia, thus contain either single or more type of microbes together. This was detected and confirmed by culturing of blood into the medium. Bloodstream is a primary type of infection only, because that microbe in the blood is primarily contact with the patients' blood, but later it may cause serious secondary infection problem to the tissue or organs of the patient.

The severity of the infection depends upon the microbial pathogenicity and the patient's host defense immune mechanism.[38] Emergence of highly protective protocols, high tech equipments, aseptic conditions not enough to reduce the SSI, BSI, and HAI due to increased use of aggressive devices and immunosuppressive drugs. Most of the BSI is identified in patients who are all admitted in the Intensive Care Unit, because they have higher chance to get infection compare to the other hospitalized patients. Recently, nosocomial BSI is the most frequently encounter in the ICU patients. Incidence of BSI cause severe life threatening organ or tissue damage and infection, thus raise the length of stay and mortality, this happen because of treatment delay and improper antimicrobial treatment.[39]

In atherosclerosis, the pathogenesis was caused by the oral bacteria present in the blood stream play a major role. Thrombus formation is functionalized by platelets and prostaglandin synthesis which was affected by the interruption of the oral bacteria present in the blood stream, thus induce atherosclerosis affects the blood coagulation function. This lead to infarction in cerebral and myocardial tissue, thus the cardiovascular disease is indirectly caused by continuous entry of bacteria into the blood stream.[40]

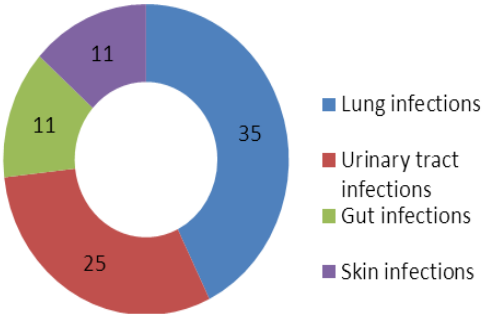

Figure 3: Common infections that leads to sepsis.

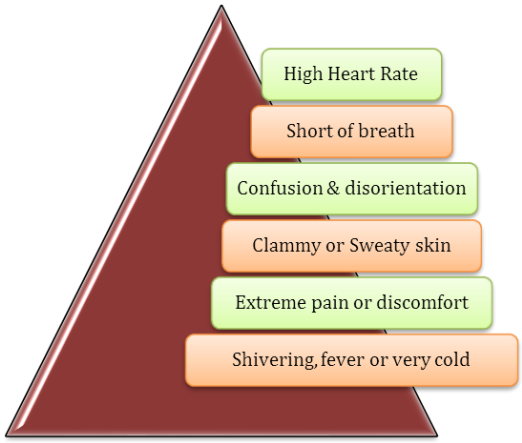

Figure 4: Signs and Symptoms of Sepsis.

Microbes responsible for SSI

Surgical Site Infection is cause by various kind of microbes that under aerobic or anaerobic from the exogenous or endogenous environment around the ICU or hospital etc. In the bacteremia patient have one or more type of microbial population; those are gram-positive cocci and gram-negative bacteria including *Escherichia coli*, *Staphylococcus epidermidis*, *S. haemolyticus*, *Enterococcus faecalis*, *Acinetobacter baumannii* and *Enterobacter cloacae*. According to the recent study, bacteremia is the second most predominant condition develops among patient after surgery.[41]

In ICU, most primary risk factor established because of long staying in hospital, poor nutritional status of patients, administration of multiple antibiotics, using of indwelling catheters, ventilators, etc. These factors are causing post-operative infection in patients, which is caused by several drug resistant microbes in nosocomial infection are MRSA, Multidrug resistant *Escherichia coli* and multidrug resistant *Acinetobacter baumannii*.[42] In the non-immuno suppressed intensive care unit, Cytomegalovirus (CMV) reactivation is common, when the patient undergo major heart surgery. In post-operative period, they may have a high risk of CMV reactivation infection.[43]

Wound is a common and primary infection after surgery, thus contain multiple kind of microbial load. Prevention of post-operative wound infection is effective when isolate and identify the causative microbes successfully. This may have a chance to reduce the infection severity. The wound infection causing microbes *Candida albicans*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella aerogenes*, *Proteus* spp and *Streptococcus* spp.[43,44] Among these surgical site infection causing microbes, *Staphylococcus aureus* is the major post-operative infection causing microbe.[44]

Streptococci and Staphyloccocci present in wound pus, in that species *Streptococcus pyogenes* is most pathogenic. But all Streptococci sp are still sensitive against penicillin and erythromycin and upto 15% of wound infection causing microbial population is *Staphylococcus pyogenes*. *Clostridium perfringens*, *Clostridium tetani* and *Clostridium difficile* are also present in the wound cause gas gangrene, pseudo membranous colitis. Some aerobic gram negative bacilli *Escherichia coli*, *Klebsiella pneumoniae* and *Bacteriodes* are a group of microbes create hospital acquired infection.[45]

Reduce surgical site infection

Even though the improvement of modern medical devices, techniques, newer and next generation antibiotic availability, sterility of the operation theater and environmental hygiene of ICU, there are more chance of infections at various levels of surgical procedures. Surgical site infection is the third most problematic infection among the hospital acquired infection. In the people economical concern, based on the health care system are important, it includes the length of hospital stay and cost. Proper preventing measures must arise to reduce the SSI.[46] Generally, surgery is a best option for some disease condition, which helps to relief from the pain while the administration of anesthesia but in some cases it disturbs the immune suppression.

Recovering from the surgery suppression immune function is highly depending upon the individual strength.[47] Reducing SSI using wound drainage is a good thing, but not able to apply constantly to all the patients, because wound drainage is differ from one to another, so that not a great idea. For a specific individual the antibiotic for that specific wound drainage is highly effective. But it creates discomfort, may increase the hospital stay and also leads high cost for the treatment. If patients have very dirty wound they are having a high chance of getting wound infection.

Figure 4: Infection control strategies.

Medical devices are help to reduce the cause of wound drainage which remove the dirt in deeper by suction process. In laparotomy wound wick is ensure wound drainage in the immediate post-operative time.[48] Pre hospital interventions include smoking cessation, pre-operative bathing and showering with 4% chlorhexidine gluconate, along with that chlorhexidine impregnated clothes used for clean, wipe etc. Finally hospital intervention including perioperative blood glucose control, hair-removal method, usage of surgical hand scrub, surgical attire, antibiotics, use of wound protectors, antibiotic-coated sutures, usage of personal protective equipments (PPEs), proper wound closure methodology, supplemental oxygen deliver and wound care practices in the hospital may reduce the SSI.[49]

Prevention of SSI is not common; it differs from hospital to hospital even person to person and patient to patient. Regular practice and proper methodology to avoid the environmental infections in the operating room and random controlled trial analysis also helps to reduce the incidence of SSI. Along with that physicians must give awareness about the risk of SSI and its effects, patient's role and relatives' cooperation during and after the surgery, which will truly help to moderate the HAI and SSI.[50]

Role of disinfectants

Disinfectants or antiseptics are established to avoid the infections which are more toxic to the microbes. The emergence of antimicrobial resistant pathogens, toxicity, high cost of health care and increased morbidity because of the unnecessary use of anti infectants are the key information's that increase the burden of HAIs.[51] Contaminated surfaces surely spread the infectious pathogen, so that disinfection usage is very important to avoid infection risk. Proper disinfectants usage also important like pre-soaked cotton or clothes or wipes are used for surface sterilization.

Improve the quality of disinfectants and changing the disinfectants frequently also minimizes the rate of infection after surgery.[52] Still hand washing is considered as a most important thing in the infection preventive protocol to avoid hospital acquired infection. Improper healthcare management among the workers or physicians is continues the infection rate. The proper hand washing may reduce the chance of infection that protocol includes the amount of hand wash usage, level of time taken for washing, etc. Inadequate knowledge and continuous hand washing without proper way lead to skin irritation and skin dryness.[53]

Operation theater practice and outpatient practice about hand washing different in the dermatology field. Post-operative infection was documented the range is 0.2-3.5% in the dermatological surgery and systemic infective complications are rare when compare to the superficial suppuration. In the dermatological surgery post-operative infection is very common, doesn't increase the patient's morbidity, thus the maintenance of strict asepsis is essential.[54]

Role of patients

Patients must know about the pre and post-surgical infection, infection site, rate of infections, antibiotics for the proper infection, maintenance after discharge from the hospital etc.

Anxiety, morbidity and expenses among patients are a major source in the post-surgical infection. Continuous surveillance of wound infection in patient by themselves and their own perception is a dangerous thing, so they must be overcome from the unaware about their surgery and to counsel the doctor properly. Inadequate communication between doctor and patient is a major threatening thing to worse the rate of infection.

Improper way of monitoring the infection also leads to a problem, because inability to fix with the antibiotic for the infection. This may leads to poor outcome after the surgery.[55] In the surgical community there are rapid advancements emerging and new surgical devices increase. Concern device and proper surgical techniques helps to reduce the harmfulness among the patients after surgery. Patient safety is an ultimate goal, so physicians and technicians must take care on their surgery process.[56]Although significant advanced method developed in the surgical techniques, equipments and advanced architecture of operating room but still the surgical site infections (SSIs) remain a burden and also

associated with increased morbidity, mortality of the patient.

The current SSI prevention approaches have only focused on the role of healthcare workers and procedure related risk factors. New interventions supporting an active participative role within SSI prevention programs have not been assessed. So, empowering the patients with information they require to engage in the process of SSI prevention could play a major role for the implementation to reduce the SSI.[57]

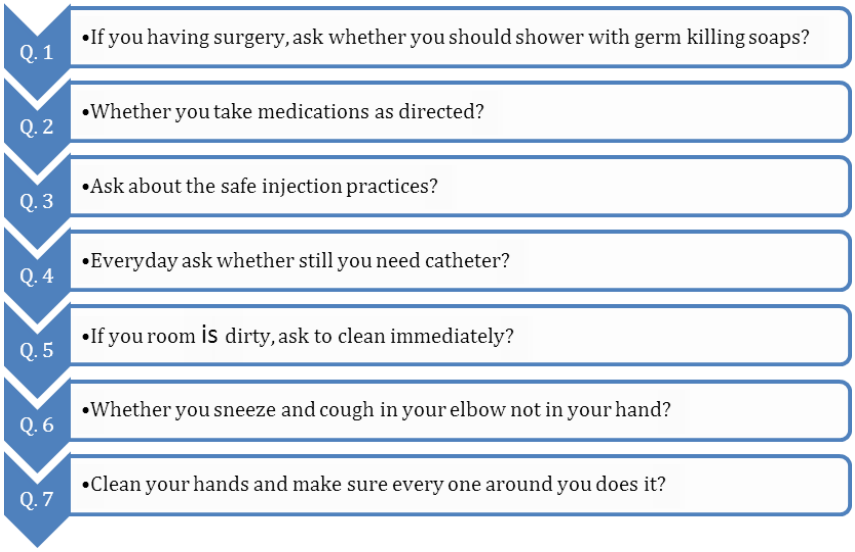

Figure 5: Patients role in infection control.

Pre, during and post anti-infective intervention

The incidence of surgical wound infection is caused many factors, the main role played by surgeons and hospital environment. Physician must go through patient parameters those are, age of the patient, patients having diabetics mellitus, malignant disease, obesity, malnutrition, length of preoperative stay, surgery urgency. In SSI, the degree of wound infection is categorized by four classes: clean, clean-contaminated, contaminated and dirty. This type of classification helps to predict the rate of infection, type of infection, prediction of antibiotic selection for the infection and the treatment.[58]

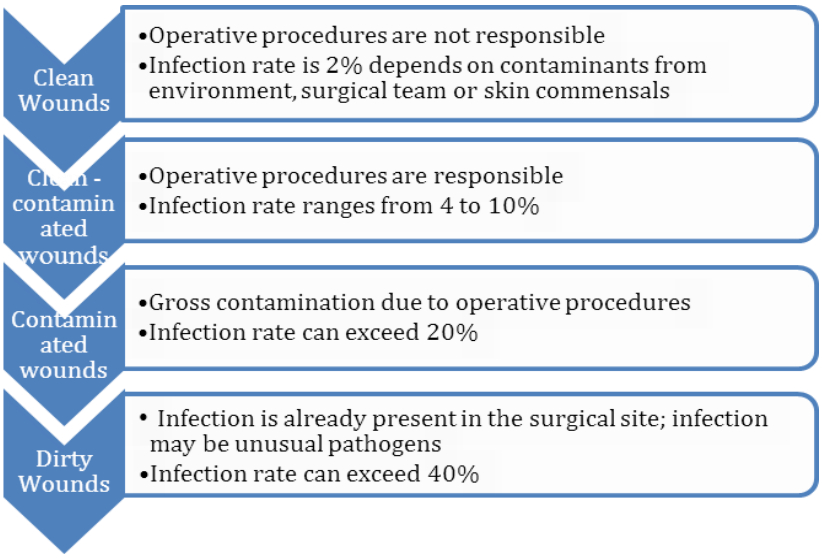

Figure 6: Classification of wounds.

During the major respiratory and cardiac surgery, level of anesthesia is very important because pulmonary volume, gas exchange, respiratory function monitoring for pre dispose patients. In post-operative patients the cardiac surgery is trigger the respiratory complications. In some cases, patients need physiotherapy to recover from the complications after surgery in the ICU itself.[59] The requirement to reduce SSI is currently a considerable attention and need more research regarding this infection.

SSI reduction will support to decrease the unnecessary morbidity and associated socioeconomic concerns for the patient and their family. Recommendations include some modified risks factors in the preconception period, ensuring a sterile environment, aseptic surgeries, meticulous homeostatic methods and the use of antimicrobial prophylaxis to reduce the prevalence of infection. An organized surveillance of wound system may help to reduce the rate of wound infection in a successful manner.[60] At the alkaline pH environment, the bacterial population is very high, because that is the favorable condition for the bacterial growth.

Colonization of bacteria on the wound creates inflammation it leads to chronic wound. The wound pH is most favorable for bio-burden, thus increase the rate of wound infection, leads to delaying of wound healing. Wound pH is one of the major factors to identify the presence of microbial population in an easy and quick way, this help to conclude the antibiotics and treatment.[12] Patients should know about the risk factors for the SSI, the factors are smoking, alcoholic, elder age group people, history of patient and disease state, etc. In spine surgery carry more risk of acquire infection than in other orthopedic procedures.

Higher range of infection is major thing because of complicated procedures and prolonged time of surgery involved in spine injury.[61] Infection complication reason is related to the operation stress, intestinal mucosa damage, intestinal flora imbalance, local immune system dysfunction and the bacterial transfer. Administration of antibiotic through intravenous way has more effective, thus avoid preventing infections and also raise the antimicrobial resistance. So, new treatment and prevention techniques want to emerge to avoid SSI.[62]

Negative pressure dressing in healing of diabetic foot ulcers has a novel method of influencing the prolonged wound environment in such a way that it reduces the bacterial burden and chronic interstitial wound fluid, increases vascularity and cytokine expression.[63]After surgery must increase the life and give quality life maintenance, the outcome patient always expect and require and the patients also be aware about the preventive measures after surgery. Post-operative care should include the recovery process after surgery to the elderly age people.[16]

Essential surgery always consists of general, limited cost surgical interventions that save the patient life and relief from the life threatening problems this must be provided by the every hospital to the patients. From the International Surgical Body, fifteen essential surgical interventions were announced.[17] In the post traumatic knee stiffness is a major condition which require accurate injury assessment because to control the drainage this deduce the risk of post-operative infections.[64]

After surgery, Enhanced Recovery after Surgery (ERAS) program gives best outcome among patients. This implementation program includes interaction with patients after surgery, thus helps to overcome from their hurdles facing post-operative infection among patients.[65] Some health expert introduce Mobile Health (mHealth) smart phone application to monitor the patients day today status after discharge from the hospital, this system is highly reduce the risk of post-surgical infection.[55]

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