International Journal of Pharmaceutical Science Invention
ISSN (Online): 2319 – 6718, ISSN (Print): 2319 – 670X
www.ijpsi.org
Volume 1 Issue 1 ||| December. 2012 ||| PP.11-15

Root cause analysis in surgical site infections (SSIs)

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ABSTRACT*: Surgical site infections (SSIs) are wound infections that usually occur within 30 days after invasive procedures. The development of infections at surgical incision site leads to extend of infection to adjacent tissues and structures.Wound infections are the most common infections in surgical patients, about 38% of all surgical patients will develop a SSI.The studies show that among post-surgical procedures, there is an increased risk of acquiring a nosocomial infection.Root cause analysis is a method used to investigate and analyze a serious event to identify causes and contributing factors, and to recommend actions to prevent a recurrence including clinical as well as administrative review. It is particularly useful for improving patient safety systems. The risk management process is done for any given scenario in three steps: perioperative condition, during operation and post-operative condition. Based upon the extensive searches in several biomedical science journals and web-based reports, we discussed the updated facts and phenomena related to the surgical site infections (SSIs) with emphasis on the root causes and various preventive measures of surgical site infections in this review. The web based pubmed, openpdf, Elsevier and other journals were used to retrieve the information.*

Keywords—*Surgical Site Infections (SSIs), Patient Safety Systems, Root Cause Analysis, Risk Management Process.*

I. INTRODUCTION

Surgical site infections are the most common health care associated infections. A number of factors affect the occurrence of these infections such as old age, disease, malnutrition caloric, non-compliance with the standard and transmission based precautions, use objects contaminated during surgery, extended stay in hospital and the long duration of surgery. Root cause analysis is a method used to investigate and analyze a serious or sentinel event (an unexpected occurrence involving death or serious physical or psychological injury or risk) to identify causes and contributing factors, and to recommend actions to prevent a recurrence including clinical as well as administrative review. It is particularly useful for improving patient safety systems (Sherwin, J., 2011).[1] The common pathogens cause infections (sepses) in surgery are Staphylococcus aureus, Streptococcus milleri, Enterococcus faecium, Escherichia coli, Candida albicans and Pseudomonas aeruginosa. Root cause analysis focuses primarily on system and processes not individual performance (Holloway, 2004)[2]. The organisation include perioperative nurses, surgeons, anaesthesiology care provides, risk managers, quality improvement coordinators and other related staff members should overhaul perioperative assessment care plans and multidisciplinary planning records to reduce the risk of sepsis in the patients(Anderson, Fagerhaug and Beltz, 2010)[3].

The main cause of the appearance of surgical wound infection is the entrance of a microorganism during surgical intervention. A result of study conducted in United States shows that from all the nosocomial infection the surgical wound infection is most common. Reports show about 14 to 16% wound infection occurs in hospitalized patients and 38% of the surgical patients (Owens & Stoessel, 2008)[4]. During the surgical procedure microorganisms can penetrate the body through various ways such as contaminated environment, which mainly includes operating room and non-sterile techniques like unsanitary hands and non-sterile items. Moreover, at the same time if patient's body is not sterile, that is also act as a door for entry of microbes. Most

surgical wound infections originate at the time of surgery. The risk of infection can be determined by several factors such as the amount of tissue devitalized during surgery, metabolic factors such as whether the patient is obese or suffers from diabetes and technical issues such as heavy bleeding (Lee & Bishop, 2010).[5] Various sources of causative organisms can be: incorrect hand washing and perioperative cleansing with antiseptic by operating theater personnel or if the staff has dermatitis on their hands, it increases the risk of infection, as the bacteria are highly colonized in the lesions (Brown, 2005).[6]

Risk management is an organized effort to identify, assess and reduce physical and financial risk to patients, staff, visitors and organizational assets. Risk management in healthcare supports growth in the quality and patient safety. The risk management professional's role should focus on the activities, associated with loss prevention and reduction of risk identification, management of serious adverse events, staff education, development, policy and procedure review. The main function of risk management in acute care setting are to identify areas of operational and financial risk or loss to a health care facility and its patients, visitors and employers and second is to implement measures to lesser the effects of unavoidable risks and loses, prevent the recurrences of these effects and cover inevitable loses, at the lower cost. The risk management process should be done for the given scenario in three steps: perioperative condition, during operation and post-operative condition. Operation characteristics that may influence the risk of developing surgical site infection in an operating room are perioperative shaving, perioperative skin preparation, duration of operation ,antimicrobial prophylaxis, operating room ventilation and instrument processing (Anderson, Fagerhaug and Beltz, 2010)[3].In Perioperative condition work should begin with the study of non-invasive arterial physiology including ankle brachial indices or graft pulses, distal pulses and arterial wave form analysis by duplex ultrasonography. Computed tomographic angiography (CTA), Magnetic Resonance Angiography or an arteriogram provides anatomic information for the needed revascularization procedure (Burke, 2003).[7] There are some other complications which may occurs in surgical procedures like myocardial infarction (heart attack), cardiac arrhythmias (irregular heartbeats), haemorrhage (bleeding), wound infection, leg edema (swelling of the leg), thrombosis (clot in the leg), pulmonary edema (fluid in the lungs), bleeding at the catheter insertion site (usually the groin), blood clot or damage to the blood vessel at the insertion site (PTA), restenosis (blockage in the blood vessels), nerve injury, graft occlusion (blockage in the graft used in bypass surgery).The risk management process should be done for the given scenario in three steps: perioperative condition, during operation and post-operative condition.

II. PERI-OPERATIVE CONDITIONS:

Medical conditions, such as high blood pressure, heart disease, or diabetes are treated prior to bypass surgery to obtain the best surgical result. Regular medications, such as blood pressure drugs or diuretics, may be discontinued in some patients. Routine pre-operative blood and urine tests are performed when the patient is admitted to the hospital. The risk of death or heart attack is about 3–5% in all patients undergoing peripheral vascular bypass surgery. The equipment or instruments like forceps, needle holder, scissors, and tourniquet cuff and so on should be properly sterilized before surgery (Zelenock, Huber, Messina, Lumsden & Moneta, 2006).[8] Hair removal from the surgical area before surgery using a safer method (electric clippers or hair removal cream, not a razor) helps to reduce the infection at the site of surgery. Medical research has shown that shaving with a razor can increase the risk of infection. It is safer to use electronic clippers or hair removal cream. Medical research has shown that patients whose body temperatures drop during surgery have a greater risk of infection and their wounds may not heal as quickly. Hospital staff should make sure that patients are actively warmed during and immediately after surgery to prevent drops in body temperatures. The administration of blood products carries various risks, including transmission of virally mediated infectious diseases. However, other equally as serious blood transfusion related complications can occur. The possibility of bacterial contamination of blood products is a rare but potentially fatal complication, with immediate manifestations and often tragic results. (Bjune G, Ruud TE, Eng J. 1984)[9]

III. OPERATIVE CONDITIONS

During bypass surgery the patient should remove all jewellery and other objects that come in contact with surgical procedure. Anaesthesiologist should check heart rate, blood pressure, breathing, and blood oxygen level during the surgery. A catheter should be inserted into the bladder to drain urine and a dose of antibiotics should give through IV (intravenously) to prevent the infection. The surgical site should be cleaned with an antiseptic solution. The incision should be sutured properly and a sterile bandage or dressing is applied on it. Staff in the operation room should wear glows, gowns and masks. During surgery always use sterile instruments and equipments for the surgery. Septic arteritis (inflammation in arteries) and infected grafts cause a high morbidity and mortality situation in the patient (Zelenock et. al, 2006).[8]

IV. POST-OPERATIVE CONDITIONS:

The most frequent etiologic factors for postoperative wound infections are extended spectrum B-lactamase (ESBL) producing Escherichia coli, Pseudomonas aeruginosa, Enterobacteriaceae, Staphylococcus aureus, Klebsiella spp. and Enterobacter spp. (Bissett, L. (2007).[10] After the procedure or in postoperative condition patient should take to the recovery room for observation. Patient environment should be sterilized so, that it minimizes the risk of sepsis and visitors who come to see the patients should also wear masks or should not allowed more visitors to come in direct contact with patient. After observation blood pressure, pulse, and breathing should be stable and pulses below the surgical site is checked frequently to assist in monitoring blood flow to the limb. The leg is monitored for colour (pale or pink), warmth (coolness), sensations of pain, and movement. The surgical incision may be tender for several days after the procedure. Medication such as such as aspirin or clopidogrel (Plavix), should be given after the surgery to relief the pain and sepsis, IV medications to help blood pressure, heart rate, and to control the problems with bleeding. As the condition stabilizes, these medications will be gradually decreased and discontinued. When doctor determines the patient is fine then he/she is to be moved from the ICU to a postsurgical nursing unit. The doctors, nurses and staff should check the patient 4-5 times in a day. The infections can be occurs in synthetic peripheral bypass vascular graft and it carries high morbidity rate. The risk of complications is high including haemorrhage, limb ischemia, amputation, revision, or infection. The risk factors for graft infection are similar to those for wound infection and it includes obesity, diabetes. The most common pathogen in graft infection is Staphylococcus aureus, which is responsible for 35% of graft infections. Other common organisms in these infections include coagulase negative Staphylococcus, Streptococcus milleri, Enterococcus faecium, Escherichia coli, Bacteroides fragilis, Candida albicans and Pseudomonas aeruginosa. Grafts that require groin incisions have the greatest risk for infection, possibly due to contamination by bowel flora at the time of implantation. The clinical perspective, biofilms are a major problem; these structures display greatly increased resistance to physical and chemical insults. Crucially, biofilms are resistant to antibiotic treatment, and making them difficult to eliminate from patients and contaminated surgical equipments. (Fernandes & Prudencio, 2010)[11]

Surgical Infection Prevention provides treatments that are shown to help prevent a post-operative infection at the incision site. Getting an antibiotic within 1 hour before surgery reduces the risk of wound infections. Hospitals should check to make sure surgery patients get antibiotics at the right time Recommended antibiotics to help prevent wound infections for any surgery should be given in order to prevent a surgical wound infection. The Medical Letter. 2001. Antimicrobial prophylaxis in surgery[12.] Old wounds with dead tissue and those that involve existing clinical infection or a perforated bowel, suggesting that the pathogens causing the postoperative infection were present in the wound before the surgery. Organisms associated with surgical site infections (SSIs) such as Staphylococcus aureus (coagulase negative staphylococci), Enterococcus species and Escherichia coli are the three most frequently isolated pathogens. (Cruse PJE and R Foord. 1980, The epidemiology of wound infection)[13.] An increasing number of SSIs are caused by antimicrobial-resistant pathogens, and the incidence of fungal SSIs has risen significantly in the last decade in part because of the dramatic increase in the number of HIV/AIDS patients. For most SSIs, the source of the pathogen(s) comes from the patient's skin, mucous membranes or bowel and rarely from another infected site in the body (endogenous sources). Exogenous sources of SSI pathogens are occasionally responsible. These include organisms from members of the surgical team (e.g., hands, nose or other body parts); contaminated surfaces in the operating room, even the air; and contaminated instruments, surgical gloves or other items used in the Surgery.(Alvarado CJ. 2000)[14]. Exogenous organisms are primarily aerobic staphylococci or streptococci species (with the exception of tetanus endospores). Although fungi are widely present in the environment, they rarely cause SSIs. Infection at another site may increase the risk of spreading infection through the bloodstream. Immunocompromised patients (e.g., those with HIV/AIDS, those with chronic corticosteroid use such as occurs with asthma and heavy smokers or users of other tobacco products) are at significantly greater risk of Surgical site infections. (Lambton & Mahlmeister, 2010)[15].If gauze dressings moistened with sterile normal saline are used, the dressing should be changed using aseptic technique (sterile or high level disinfected gloves) every 8 hours to prevent the gauze from drying out.The person that manages the infection prevention and control program is responsible for ensuring that an active program to identify SSIs is implemented, that data on SSIs are analysed and regularly provided to those who can use the information to improve the quality of care (eg, unit staff, clinicians, and hospital administrators), and that evidence- based practices are incorporated into the program. (Stewart, 2011).[16]

V. THE CHAIN OF INFECTION

The chain of infection consists of six elements which is necessary for infection to occur. They are an infectious agent, reservoir, portal of exit, mode of transmission, the portal of entry and the susceptible host. In order spread the infection, this entire links should be intact. The failure of one of these elements can prevent the spread of infection (Shahid, 2011).[17]To describing the initial component of chain of infection, the agent is an

organism that responsible for causing infection in a person. The capacity of the organism to causes the disease usually depends on its pathogenicity and virulence. The ability of a microorganism to invade in the body of the host and cause disease is called pathogenicity (Nakamura, Komatsu, Yamasaki, Fukuda, Miyamoto, Higuchi, & Yamamoto, 2012)[18]. It also relays on the number of microorganisms enter in the body of the host and cause disease in his first exhibition. Some results indicates Escherichia coli is the most frequent enterobacteria (46%) with ESBL production in 72% of Enterobacteriaceae isolates from SSI.

The second link of chain of infection is Reservoir, which means all cite where the micro-organism can stay over a long period of time. It may be living or non-living organism which can grow, multiply and survive until it is transferred to a host. It is capable of causing an infection due to its ability to survive well in the warm, humid environments and it can be passed easily through the food, water, blood, hands of staff members or visitors and other clinics elements such as bed pans, bed linen, instruments, dressings, specimen containers which resulting in cross-infection (Nakamura, Komatsu, Yamasaki et al, 2012).[18] Air contaminated with dust or respiratory secretions of ESBL positive patients during breathing, talking, sneezing and coughing act as a reservoir. In this case, the patient was placed in a four-bed area, and any one of these patient may be infected or carrier. (Shahid, 2011).[17]

Portal of exit is the third step in the chain of infection. This includes the infectious agent to leaves the reservoir by body secretions. E.g, Esechericia coli leave the body through the skin and wounds; it spread infection by indirect or direct contact of the living and non-living material. Some other ways are through semen and vaginal discharge (Sussman, 2007).[19]

The mode of transmission is the next link in the chain of infection. It means the medium by which the body transmits organism from the portal of exist of the reservoir to portal of entry of the host. In the case of Mrs. G, which is located in Ward 21, mode of ESBL transmission can occur by air borne, direct or indirect contact, droplet, vehicles and vector. ESBL transmission can also be a food borne. The food can be contaminated by handlers who carry organism or either during the food production (Lee & bishop, 2010). After this, pathogen enters the body of the host through the portal of entry. The portal of entry includes the integumentary system, genitourinary tract, gastrointestinal, respiratory and circulatory system. The susceptible host is the last link in the chain of infection that may be infected with the causative agent. (Kohlenberg, 2012). [20]

VI. TRANSMISSION BASED PRECAUTIONS:

Standard and transmission based precautions are the methods that are used to control and prevent the transmission of infection and also it protect the patient and the health of workers from causative organisms which present in body fluids, blood and hospital environment (Bissett, 2007)[10]. Standard precautions for ESBL are using an aseptic technique during surgery and bandaging of the surgical wound, the use of protective equipment such as gloves, mask, gowns, eye shields, disinfection and sterilization of reusable devices and instruments, proper handling and disposal of sharps or other contaminated objects and clinical waste, proper hand washing practice before and after contact with the patient. If they were not taken it could lead to infection. Transmission-based precautions are used when standard precautions are not sufficient to reduce transmission of infection. It is used primarily for droplets or airborne and contact transmission (Shahid, 2011)[17]. Contact precautions are used where the micro-organism may transfer by direct or indirect contact with the environment of the patient or the patient. Single room is preferable, but if not available grouping in cohorts of patients can be made (keeping patients with same infection in a room) or even if this is not possible, then in Ward, the beds of patients should be more than three feet apart. In addition, the use of PPE and hand personal hygiene is essential (Brown, 2005)[6].

The Centre for Disease Control (CDC) recommends that standard precautions are sufficient to control the spread of ESBL infections. But, in acute care settings, CDC recommends that additional precautionary measures can be used when there is current ESBL transmission, current infections and a few other special circumstances. It is very important to wear gloves whenever that contact with the patient and personal effects of the patient and to wash hands before and after pressing on the patient and the environment. (Infection Control Guidelines Extended Beta Lactamase spectrum, 2012).[21]

VII. CONCLUSION

Root causes analysis of Surgical site infections depends upon a number of patient factors, including pre-existing medical conditions, amount and type of resident skin bacteria, perioperative glucose levels, core body temperature fluctuations, and perioperative, operative and postoperative care,Nutritional status, poor, Diabetes, uncontrolled smoking or use of other tobacco products, obesity, coexistent infections at a remote body site, Colonization with microorganisms, altered immune response (HIV/AIDS and chronic corticosteroid use, length of perioperative stay, Perioperative shaving, Perioperative skin preparation, Duration of operation, Antimicrobial prophylaxis, Operating room ventilation, Instrument processing (cleaning, HLD or sterilization), foreign material in the surgical site, surgical drains and surgical technique. For that reason, caregivers should

strive for early identification of patients with risk factors amenable to intervention to minimize the risk of wound contamination in all surgical cases and to support host defences throughout the continuum of care. These and other well best practices care we must provide our patients every day. Direct healthcare providers (such as physicians, nurses, aides, and therapists) and ancillary personnel (such as house- keeping and equipment-processing personnel) are responsible for ensuring that appropriate infection prevention and control practices are used at all times (including hand hygiene; strict adherence to aseptic technique; cleaning and disinfection of equipment and the environment; cleaning, disinfection, and sterilization of medical supplies and instruments; and appropriate surgical prophylaxis protocols).

The infection prevention and control team should manage the infection prevention and control program in acute care setting and is responsible for ensuring an active program to identify SSIs The program should be implemented based on the SSIs data and regularly analysed the information to improve the quality of care to the unit staff, clinicians, and hospital administrators. The evidence should be based on good practices. Direct healthcare providers such as physicians, nurses, aides, and therapists and ancillary personnel such as house-keeping and equipment processing personnel are responsible for ensuring that appropriate infection prevention and control practices. These people should use hand hygiene, strict adherence to aseptic technique, cleaning and disinfection of equipment and the environment, cleaning, disinfection, and sterilization of medical supplies and instruments and also use appropriate surgical prophylaxis protocols.

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