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Review Article

Incidence, risk factors and Molecular characterization of antimicrobial resistance in bacterial flora associated with surgical site infection in a tertiary care hospital

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ABSTRACT

Introduction: Surgical site infections (SSI) are the leading type infection among hospitalized patients in the low-middle income countries. SSI constitutes a major public health problem and are the second most frequently reported nosocomial infections. They are responsible for increasing the treatment cost, length of hospital stay and significant morbidity and mortality.
Aims & Objectives: To determine the incidence of SSI among patients undergoing general surgeries in the hospital. To analyse the risk factors in SSI & to study AST pattern of isolates and correlate with clinical outcome of these patients.
Materials and Methods: This literature was conducted to recognise the extent of studies in relation to surgical site infection procedural details of SSI, quality attributes in term of various components of SSI were assessed.
Discussion & Conclusion: This literature review elaborates the Pathogenesis, classification of SSI, associated risk factor, antimicrobial susceptibility and also demonstrate the treatment challenges in various prospective.

1. Introduction

Healthcare-Associated Infections (HAIs) is a subject of great concern of the healthcare services. Among the topographies of the HAIs, Surgical Site Infection (SSI) is directly related to surgical procedures, and is currently one of the most important among the HAIs.[1]

SSI leads to serious consequences, including increased costs due to its treatment and increased length of hospital stay. The risk of death in patients with SSI is increased when compared to those who did not develop an infection.[2]

Surgical site infection (SSI) is an infection that develops within 30 days after an operation or within one year if an implant was placed and the infection appears to be related to the surgery. Post-operative infections are the most common healthcare associated infection in surgical patients, occurring in up to 5 percent of surgical patients.[3]

The rate of SSIs is reported in numerous literatures in the range of 2.5-41.9%. The patients of SSIs have 2-11 times greater risk of death as compared to the patients having no SSI. The number of incidences reported for SSI may be different across several countries due to the various systems applied for the epidemiological control of hospital related infection.

Surgical Wound Infection Task Force USA published a standardized application for the SSI in 2015 which includes “the existence of purulent drainage; impulsive drainage of fluid, apart from the culture sensitivity for specific bacterial specie; localized symbols of contagion for outward sites or radiological verification of infections from deep sites; an eruption/abscess or additional infection of direct surgical procedure; or an identification of an infection by a surgeon.[4]

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1.1. Signs and symptoms of surgical site infections

Any SSI may cause redness, delayed healing, fever, pain, tenderness, warmth, or swelling. These are the other signs and symptoms for specific types of SSI:

1. A superficial incisional SSI may produce pus from the wound site. Samples of the pus may be grown in a culture to find out the types of germs that are causing the infection.
2. A deep incisional SSI may also produce pus. The wound site may reopen on its own, or a surgeon may reopen the wound and find pus inside the wound.
3. An organ or space SSI may show a discharge of pus coming from a drain placed through the skin into a body space or organ. A collection of pus, called an abscess, is an enclosed area of pus and disintegrating tissue surrounded by inflammation. An abscess may be seen when the surgeon reopens the wound or by special X-ray studies.[5]

1.1.1. Types of surgical site infections

Surgical Site infection is categorized into three different types according to The Centers for Disease Control and Prevention (CDC's) and National Nosocomial Infections Surveillance System (NNIS) characterized by Superficial incision which include only the skin and subcutaneous tissue, whereas Deep incision in which infection penetrate in deep tissue, such as facial and layer of muscle; It also includes infections which involve both superficial and deep incision sites, organ/space SSI drainage through incision. While organ/space defined as an infection in any organ or space other than the incision site. Literature Survey conducted by Isik et al. reports the incident rate in superficial incision is found to be 42.19%, which is more frequent, followed next in frequency by deep incision having an SSI 40.1% while organ space shows 17.71% rate of infection.[6]

1. Superficial incisional SSI. This infection occurs just in the area of the skin where the incision was made.
2. Deep incisional SSI. This infection occurs beneath the incision area in muscle and the tissues surrounding the muscles.
3. Organ or space SSI. This type of infection can be in any area of the body other than skin, muscle, and surrounding tissue that was involved in the surgery. This includes a body organ or a space between organs.

2. Microbiology of SSI

Distribution and pathogens of surgical site infectios (SSIs) has not changed, Staphylococcus aureus, coagulase negative staphylococci (CONS), Enterococcus spp., and Escherichia coli remain the most frequently isolated pathogens. An increasing proportion of SSIs are caused by antimicrobial-resistant pathogens, such as Methicillin-resistant S. aureus (MRSA), or by Candida albicans.

The increased proportion of SSIs caused by resistant pathogens and Candida spp. may reflect increasing numbers of severely ill and immunocompromised surgical patients and the impact of widespread use of Broadspectrum antimicrobial agents. Outbreaks of SSIs have also been caused by unusual pathogens, such as Rhizopus oryzae, Clostridium perfringens, Rhodococcus bronchialis, Nocardia farcinica, Legionella pneumophila and Legionella dumoffii, and Pseudomonas multivorans. These rare outbreaks have been traced to contaminated adhesive dressings, elastic bandages, colonized surgical personnel, tap water, or contaminated disinfectant solutions.

When an outbreak of SSIs involves an unusual organism, a formal epidemiologic investigation should be conducted. MRSA (Methicilin – resistant Staphylococcus aureus) is a resistance strain of Staphylococcus aureus microbes (example penicillin and tetracycline). The type of surgery, prolonged hospital stay and also a long time in ICU can increase the risk of being infected by MRSA. Occasionally, MRSA gets into the body through breaks in the skin such as cuts, wounds, surgical incisions or indwelling catheters. At the same time MRSA has the ability to survive in dry, dusty environment, it can also be spread through airborne, and therefore the most common infection route between patents is health care workers.[7]

3. Pathogenesis

Microbial contamination of the surgical site is a necessary precursor of SSI. The risk of SSI can be conceptualized according to the following relationship, exogenous and endogenous sources.

3.1. 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

Table 1: Classification of wounds

Wound Type	Class	Definition/Major Characteristics of Respective Classes
Clean	I	No inflammation stumbles upon and the gastrointestinal (GI), respiratory, genital & urinary tract is not involved.
Clean contaminated	II	Operative method involved a colonized viscera or cavity (opening) of the body, although with controlled and elective situations with nominal spillage. Furthermore, emergency and urgent cases are clean otherwise, inconsequential break in technique
Contaminated	III	Operative procedures are carried out with major interruption/breaks in desolate/aseptic/sterile method (like open cardiac massage) or gross/foul spillage/ drain from the GI tract, access into genitourinary or biliary system in the existence of contaminated bile/urine contents and incisions with non-purulent, sensitive and acute inflammation are integrated into this group.
Dirty	IV	Dirty wounds are demonstrated with surgical processes mainly involved active infections prior to surgery.

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.[8]

3.2. *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 floras are primarily aerobes, especially gram-positive organisms (e.g., staphylococci and streptococci).[8]

4. *Risk Factors Associated with Surgical Site Infections (SSI's)*

There are four main factors which influence the infection rates in surgical wounds, they include, Patient variables, Preoperative preparation, Operative procedure and Postoperative care. From these factors, the following were identified as the main risk factors for SSI's.[9]

4.1. *Patient variables*

4.1.1. *Diseases*

The contribution of diabetes to SSI risk is controversial, because the independent contribution of diabetes to SSI risk has not typically been assessed after controlling for potential confounding factors. Also, increased glucose levels in the immediate postoperative period were associated with increased SSI risk.

More studies are needed to assess the efficiency of perioperative blood glucose control as a preventive measure.[8]

4.1.2. *Hyperglycaemia and hypoglycaemia*

Elevated blood sugar concentration impaired the function of phagocytic cells in experimental studies. Constant checking of blood sugar levels for patients with diabetes is important to maintain the blood sugar at a constant level. Intraoperative and postoperative blood sugar control remains a logistical problem. Furthermore, the ideal blood sugar level remains undefined. It generally is agreed that maintaining Euglycemia (i.e., normal blood glucose concentration) for the patient is desirable.

4.1.3. *Weak immune system*

The immune system is the part of the body that fights infection. For some type of operation, severe protein-calorie malnutrition is crudely associated with postoperative nosocomial infection, impaired wound healing. The immune system may be weakened by radiation, poor nutrition, certain medications (anti-cancer medicines or steroids). Weight and age may also decrease the ability to respond to injury.[9]

4.2. *Preoperative care*

4.2.1. *Prolonged hospital stay*

Prolonged perioperative hospital stay is frequently suggested as a patient characteristic associated with increased SSI risk. However, the length perioperative stay is a likely surrogate for severity of illness conditions requiring inpatient work-up and therapy before the surgery.

4.2.2. *Perioperative transfusion*

Perioperative transfusion of leukocyte- containing allogeneic blood components is an apparent risk factor for the development of postoperative bacterial infection including SSI. However, there is currently no scientific basic for withholding necessary blood transfusion from surgical patients as a means of either incisional or organ/ space SSI risk reduction.

4.3. Operative procedure

4.3.1. Type of surgery

When a surgery has to be done on an infected wound, the chances of SSI are increased. An emergency surgery on traumatic injuries and over 3 hour's surgery also increases the risks of SSI. It may also include surgeries also done on certain body organs, such as the stomach or intestines (bowels).

The risk may be greater if an object pierced through the skin and into an organ. SSI is likely to occur after an open surgery than a laparoscopy surgery. Drains and blood transfusion may increase the chance of bacteria reaching the wound causing Surgical Site Infection.

4.3.2. Foreign objects

Patients involved in an accident, usually some foreign objects, such as glass or metal or dead tissues present in the wound may delay wound healing. It's also possible to have SSI if there is an infection on another part of the body or a skin disease.

4.3.3. Post-Operative care

The type of postoperative incision care is determined by whether the incision is closed primarily, left open to be closed later, or left open to heal by second intension. When the wound is closed primarily, it is covered by sterile dressing for at least 24-48 hours therefore reducing the chances of infection. When the surgical incision is left open for a few days before it is closed (delayed primary closure), it is likely for the site to be infected or patient's condition may prevent primary closure, (e.g. edema at the site).[10]

4.3.4. Asepsis

There are several aseptic agents available for preoperative preparation of the skin at the incision site. Alcohol is considered to be the most available, inexpensive and the most rapid-acting skin antiseptic. Before the skin is prepared, it should be free of gross contaminations (i.e soil or dirt). The skin is prepared by applying an antiseptic in concentric circles. The prepared area should be large enough to extend the incision or create new incisions or drain site if necessary.

4.3.5. Mobile phones

Mobile phones have been the source of communication within the hospital. Hospital operating rooms (OR) and intensive care units (ICU) are the workplaces that need highest standard of hygiene, also the same requirements for the personnel working there and the equipment used by them. However, mobile phones are used routinely all day long but not cleaned properly as healthcare workers may/do not wash their hands as often as they should. They found out that healthcare workers hands and their mobile phones were contaminated with various types of microorganisms. Mobile phones used by healthcare workers may be the source of nosocomial infections in hospitals.

5. Discussion & Conclusion

Among health care associated infections, SSI is ranked second. Their incidence rate may vary in several countries due to the various system integrated in the epidemiological control of hospital associated infection.

Several studies conducted in Pakistan to find out the most common pathogen involved in SSI. Bashir et al. reported in their studies that E. coli found in 33.33% cases followed next in frequency by Staphylococcus aureus and Klebsiella in 20%, Proteus in 13.33%, Pseudomonas in 6.66% cases. While Bibi et al., also reported E. coli (33.8%) as a most common pathogen followed by Pseudomonas aeruginosa (16.9%) and Staphylococcus aureus (15.5%).[11] Similarly, Qaiser et al. also report the frequency of the isolated organisms in which Escherichia coli shows 40.7%, followed by Pseudomonas aeruginosa 26.31% and Staphylococcus aureus 19.73%.[12] All these studies highlight the prevalence of E. coli as the causative agent of SSI along with Pseudomonas aeruginosa, Staphylococcus aureus and Klebsiella. On the contrary basis, CDC also defined the most common pathogen associated with SSI is S. aureus. Likewise, another study carried out in Bangalore demonstrated that Staphylococcus aureus (S. aureus) was the most common pathogen followed by Escherichia coli and Coagulase Negative Staphylococcus.[13]

In this Literature review, certain examples are included to evaluate the relation of SSI to their risk factors like Ismat et al., reported in their study that diabetic patient undergoing Cholecystectomy is more likely associated to cause wound infection (11.67%) as compared to the nondiabetic patient (6.67%).[14]

Cheng et al., conducted a study to show the incidence rate of SSI is more in emergency surgeries (8.4%) then the elective surgeries (2.5%).[15] Fan et al., illustrates an example showing the relation of SSI with different surgical procedure according to this, abdominal surgery has a higher rate of SSI (8.3%, 95% CI: 6.5-10.0) in contrast to the orthopaedic surgery has the lowest SSI rate (1.0%, 95% CI: 0.5-1.6).[16] High risk of SSI associated with an emergency C-section as compared to the elective C-section.[17] Chattopadhya et al. conducted a study to show the incidence rate, according to the degree of contamination like 3.50% in clean wound, 6.77% in clean contaminated, and in contaminated or dirty wounds 14.58% cases are reported while the overall rate reported for SSI was 5.54%.[18]

6. Prevention of Surgical site infection (SSI)

Physician, Pharmacist and other related personnel's can minimize the risk of surgical site infection by providing guidance to the patient who undergone to surgery, help them to select the appropriate postsurgical wound care products, the array of accessible resources, and provide knowledge about wound care. Pharmacist role is considered crucial in optimizing the healing outcome through appropriate and targeted drug services; education and counselling under specific condition and with respect to the patient's need.[19]

7. Guidelines of SSI are mainly built to precise standards of pharmaceutical utilization

1. Administration of prophylactic antibiotics prior to surgery within 1 hr.
2. Selection of suitable prophylactic antibiotics in accordance with specific clinical condition.
3. Discontinuation of prophylactic use of antibiotics in 24 hrs following completion of surgical intervention.
4. Preoperative control of serum glucose levels in major surgeries of cardiovascular type.[19]

8. Conflicts of Interest

All contributing authors declare no conflicts of interest.

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None.

References

1. Centers For Disease Control And Prevention (CDC). Procedure-Associated Module: surgical site infection event [Internet]. Atlanta; 2016. Available from: http://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.
2. Franco LMC, Ercole FF, Mattia AD. Infecção cirúrgica em pacientes submetidos a cirurgia ortopédica com implante. *Revista SOBECC*. 2015;20(3):163–70. doi:10.5327/z1414-4425201500030007.
3. Wood G, Haber J. ursing research : methods, critical appraisal, and utilization. In: 5th Edn.. vol. 425. St. Louis, Mo. : Mosby; 2019. p. 428–83.
4. Afifi IK, Labah EA, Ayad KM. Surgical site infections after elective general surgery in Tanta University Hospital: Rate, risk factors and microbiological profile. *Egypt J Med Microbiol*. 2017;18:98–101.
5. Isik O, Kaya E, Dundar HZ, Sarkut P. Surgical Site Infection: Reassessment of the Risk Factors. *Chir*. 2015;110:457–61.
6. Singh R, Singla P, Chaudhary U. Surgical site infections: Classification, risk factors, pathogenesis and preventive management. *Int J Pharm Res Health Sci*. 2017;2:203–14.
7. Perttunnen J, Sapsford R, Abbott P. MRSA- Patient in Operation (slide show). *Research Methods for Nurses and the Caring Professions*. 2017;p. 108–108. Available from: http://generation.jamk.fi/generation4/index_popup.asp?id=5199&course=519934.
8. Seltzer J, Mcgrow K, Horsman A, Korniewicz D. Awareness of Surgical Site Infections for Advanced Practice Nurses. *AACN Adv Crit Care*. 2019;13(3):398–409.
9. Jan WA, Khan SM, Jehanzeb M, Muazzam. Surgical site infection and pattern of antibiotic use in a tertiary care hospital in Peshawar. *J Ayub Med Coll Abbottabad* . 2010;22:141–5.
10. Ahmed M, Alam SN, Khan O, Manzar S. Post-operative wound infection: a surgeon's dilemma. *Pak J Surg*. 2007;23:41–7.
11. Bashir J, Sahito RA, Abbasi MA, Jabeen A. Surgical site infection: Evaluation of causative organisms involved. *Prof Med J*. 2015;22:181–5.
12. Bibi S, Channa GA, Siddiqui TR, Ahmed W. Pattern of bacterial pathogens in postoperative wounds and their sensitivity patterns. *J Surg Pak Int*. 2012;17:164–7.
13. Golia S, Kamath B, Nirmala A. A study of superficial surgical site infections in a tertiary care hospital at Bangalore. *Int J Res Med Sci* . 2014;2(2):647–52. doi:10.5455/2320-6012.ijrms20140552.
14. Ismat U, Khan A, Nawaz A, Mansoor R, Malik AA. Surgical Site Infection in Diabetic and Non-Diabetic Patients Undergoing Laparoscopic Cholecystectomy. *J Coll Physicians Surg Pak*. 2016;26:100–2.
15. Cheng K, Li J, Kong Q, Wang C, Ye N. Risk factors for surgical site infection in a teaching hospital: a prospective study of 1,138 patients. *Patient Prefer Adher*. 2015;9:1171–7.
16. Fan Y, Wei Z, Wang W, Tan L, Jiang H. The incidence and distribution of surgical site infection in mainland china: a meta-analysis of 84 prospective observational studies. *Sci Rep*. 2014;4:6783.
17. Safi FN, Azam P. Surgical site infections, pathogens and sensitivity after emergency caesarean sections. *J Med Sci*. 2013;21:141–4.
18. Chattopadhya R, Zaroukian S, Potvin E. Surgical site infection rates at the Pontiac Health Care Centre, a rural community hospital. *Can J Rural Med*. 2017;11:41–8.
19. Centers for Disease Control and Prevention (2015) Surgical site infection (SSI) event. (2010) ASHP statement on the pharmacist's role in antimicrobial stewardship and infection prevention and control. *Am J Health Syst Pharm* . 2015;67:575–7.

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