Surgical Site Infections: Antibiotic Resistance Trends in Bacterial Pathogens

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Abstract

Introduction: *The most common microorganism cultured from SSIs is Staphylococcus aureus.When a viscus, such as the large bowel, is opened, tissues are likely to be contaminated by numerous organisms. Enterobacteriaceae and anaerobes can cause SSI after colorectal surgery. The presence of a foreign body from prosthetic surgery reduces the number of pathogenic organisms required to cause SSI. Microorganisms, which are non-pathogenic such as Staphylococcus epidermidis, may also cause SSI in such environment. The type of wound also dictates the presence of microorganisms at surgical sites.* ***Materials And Methods****: This study was a prospective observational study conducted in a hospital setting, including patients undergoing various surgical procedures. The study aimed to analyze the incidence, risk factors, and antibiotic resistance profile of bacteria associated with surgical site infections (SSI). A total of 360 patients who underwent different surgical procedures were included in the study. Patients were selected based on predefined inclusion and exclusion criteria. The National Healthcare Safety Network (NHSN) guidelines were used to define and confirm SSI cases.* ***Results****: In our study, a total of 360 patients undergoing various surgical procedures were included. About 45 cases of surgical site infection that fulfilled NHSN criteria were analyzed. Thus, the SSI rate during our study period was 12.5% (n = 360). Out of a total of 360 surgical operations, 253 were elective procedures, and the remaining 107 were emergency surgeries. A higher prevalence of SSI was observed among elective surgical procedures (85.5%) compared to emergency procedures (14.5%).Out of the 45 SSI cases, 24 (53.3%) were deep surgical site infections, 14 (31.1%) were superficial space SSIs, and 7 (15.5%) were organ-space infections.* ***Conclusion****; We strongly recommend that antibiotic therapy should be guided by antimicrobial susceptibility patterns. We recommend surveillance of SSIs periodically including incidence, aetiology, antibiotic susceptibility profile and source of infection.*

Keywords: *Antimicrobial agents, Extensively drug resistant, Multidrug resistant, Pan drug resistant.*

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INTRODUCTION

Infections caused by an invasive surgical procedure that occurs in the wound are commonly referred to as surgical site infections (SSIs).[1] It is clinically characterized as an infection that occurs within 30 days of surgery (or within a year if an implant is left in place after the procedure) and affects either the incision or deep tissue at the site of the surgery.[2] These infections can be superficial or deep incisional infections, or infections affecting organs or body spaces. SSIs are the most common infections associated with health care settings. They are associated with significant morbidity and over one-third of postoperative deaths have been reported to be linked to SSI. [3] SSI will double the duration of a patient's hospital stay and therefore increase the cost of health care.[4,5]

Contamination of wound site and pathogenicity of microorganisms, balanced against the host's immune response will determine the occurrence of SSI.[6] The organism which causes SSI—are usually derived from the endogenous environment, that is the patient skin or opened viscus). Surgical instrument or theatre environment will contaminate the site during operation leads to exogenous causes of SSI.[7] Hematogenous spread of organisms from distant sources of infection can rarely cause SSI by attachment to the prosthesis or other implant left in the operative site. The infection prevention and control practices of SSI are therefore aimed at minimizing the number of pathogens at surgical site.[8]

The most common microorganism cultured from SSIs is Staphylococcus aureus.[9] When a viscus, such as the large bowel, is opened, tissues are likely to be contaminated by numerous organisms. For example, Enterobacteriaceae and anaerobes can cause SSI after colorectal surgery.[10] The presence of a foreign body from prosthetic surgery reduces the number of pathogenic organisms required to cause SSI.[11] Microorganisms, which are non-pathogenic such as Staphylococcus epidermidis, may also cause SSI in such environment. The type of wound also dictates the presence of microorganisms at surgical sites. For instance, operations on sterile sites have less than 2%, whereas, SSI will occur more than 10% after operations in "contaminated" or "dirty" sites.[12]

Resistance patterns of SSI-associated bacteria vary globally, depending on the region, local epidemiology reports, and susceptibility testing methodology. Bacterial resistances pose a challenge and complicated the SSI treatment. Most of the data on drug resistance were obtained from high-income countries.[13,14] However, there were limited reports on the prevalence and incidence of resistant bacteria causing SSI, especially from developing countries.[15,16]Therefore, this study aimed at assessing the bacterial profile and antimicrobial susceptibility patterns of isolates among patients diagnosed with surgical site infection at Hospital.

MATERIALS AND METHODS

This study was a prospective observational study conducted in a hospital setting, including patients undergoing various surgical procedures. The study aimed to analyze the incidence, risk factors, and antibiotic resistance profile of bacteria associated with surgical site infections (SSI).

A total of 360 patients who underwent different surgical procedures were included in the study. Patients were selected based on predefined inclusion and exclusion criteria. The National Healthcare Safety Network (NHSN) guidelines were used to define and confirm SSI cases.

Inclusion Criteria:
Patients undergoing elective and emergency surgeries.
Patients who developed an SSI during hospitalization.
Age 18 years and above.

Exclusion Criteria:
Patients with pre-existing infections at the surgical site.
Patients who underwent minor outpatient procedures.
Patients who were lost to follow-up before SSI assessment.

Data Collection:
Demographic details including age, gender, and comorbidities were recorded. Type of surgery performed was categorized into abdominal, orthopedic, pelvic & urogenital, breast & axilla, and neurosurgeries. The depth of infection was classified into deep surgical site infections, superficial SSIs, and organ-space infections. Risk factors including type of wound, duration of surgery (>2 hours), presence of diabetes, and hospital stay duration (>7 days) were documented. Postoperative care and antibiotic administration details were collected. Details regarding wound dressing protocols and infection control measures were recorded.

Microbiological Analysis:
Wound swabs were collected aseptically from infected surgical sites. Samples were cultured on standard microbiological media, and bacterial isolates were identified using conventional biochemical tests. Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method according to CLSI guidelines. Minimum inhibitory concentration (MIC) values were determined for multidrug-resistant strains. Molecular methods such as PCR were used to detect resistance genes in selected bacterial isolates.

Sample collection
During the study, surgical wound samples were collected from in-patients at the Hospitals. The swab samples were collected before wound dressing. They

were inoculated aseptically into sterile nutrient broth as transport medium and were transported to the laboratory within 48 h for analysis. The samples were analyzed using the standard bacteriological media like blood agar, heated blood agar, mannitol salt agar, MacConkey agar, etc. All the bacterial isolates thus obtained were characterized and identified by studying their cultural and morphological features from the results of Gram staining reaction, serological and biochemical tests such as catalase, coagulase, motility, oxidase, indole, citrate utilization, urease, carbohydrate oxidation/fermentation etc described by Cowan.

Antibiotic susceptibility test
Only the conventional antibiotics regularly available for frequent use in the study area were considered for the study. The diffusion technique was employed to determine the antibiotic susceptibility pattern of the isolates to the selected antibiotics such as penicillin (11 μg), ampicillin (10 μg), tetracycline (10 μg), streptomycin (25 μg), cotrimoxazole (25 μg), cloxacillin (10 μg), colistin (10 μg), erythromycin (10 μg), gentamycin (10 μg), chloramphenicol (30 μg), and nalidixic acid (30 μg). The multi-antibiotic discs were commercially prepared by Abtek. The antibiogram was performed in accordance with standards described by the National Committee for Clinical Laboratory Standards.

Standardization of inoculums
Four pure colonies of each isolate on a 24 h plate culture were randomly selected and inoculated into 2 mL of sterile peptone water broth in Bijou bottles. This was incubated at 37°C for 6 h and the turbidity was adjusted by serial dilution in phosphate buffer saline

(pH 7. 2) to match an opacity tube containing 0. 5 mL of 1% barium chloride in 1% suplhuric acid (a Mc Farlands 0.5 barium sulphate standard containing 10 5 cfu/mL of the inoculums). One milliliter (1 mL) of the culture dilution (bacteria suspension) was transferred into a well dried surface of diagnostic sensitivity test agar (DST) medium and tilted to spread evenly over the entire surface of the agar plate. The excess fluid was drained off and dried in incubator for less than 15 min. Multi-antibiotic discs were then placed on the surface of the inoculated plate, placed in a refrigerator to allow proper diffusion of the antibiotics and incubated aerobically at 37°C for 18 to 24 h (over-night). S. aureus NCTC 6751 and E. coli NCTC 10418 were used as control organisms for the sensitivity test. The diameter of the zone of inhibition was measured in millimeter. The result of each antimicrobial agent tested was reported as susceptible or resistant when the test organism was compared with the control and manufacturer's manuals for interpretation.

Multiple antibiotic resistant (MAR)
The percentage of the isolates that showed multiple antibiotic resistance was estimated and recorded.

Statistical Analysis:
Descriptive statistics were used to analyze the prevalence of SSI. The Chi-square test was used to assess the association between categorical variables. A p-value of ≤ 0.05 was considered statistically significant. Multivariate logistic regression was performed to identify independent risk factors for SSI. Kaplan-Meier survival analysis was used to evaluate time-to-infection trends post-surgery.

RESULTS

In our study, a total of 360 patients undergoing various surgical procedures were included. About 45 cases of surgical site infection that fulfilled NHSN criteria were analyzed. Thus, the SSI rate during our study period was 12.5% (*n* = 360). Out of the total 360 patients, 247 were male and 113 were female patients. Out of 247 male patients, 33 (13.4%) developed SSI, and out of 113 female patients, 12 (10.6%) developed SSI. Thus, gender difference was not an associated risk factor for SSI (x^2 = 0.15, *p*-value = 0.69, not significant).

Table 1: Gender Distribution of SSI Cases

Gender	Total Cases (n = 360)	SSI Cases	% SSI
Male	247	33	13.4%
Female	113	12	10.6%

Table 2: Age-wise distribution of SSI cases

Age group (years)	SSI (n = 45)	% SSI
18-24	4	8.9%
25-34	9	20.0%
35-60	18	40.0%
>60	14	31.1%

Age-wise distribution of SSI cases is shown in Table 2. The highest prevalence of SSI was observed in the age group 35-60 years (42.2%).

Out of the total 360 patients, 150 patients underwent abdominal surgeries, 102 patients underwent orthopedic surgeries, 68, 18, and 22 underwent pelvic & urogenital, breast & axilla, and neurosurgeries, respectively.Abdominal surgeries included laparotomy, appendicectomy, hernia repair surgery, and hysterectomy. The proportion of SSI based on the surgical site was as follows Abdomen: 24 (53.3%) ,Pelvic and urogenital surgery: 8 (17.8%) ,Breast and axilla: 2 (4.4%) ,Skin, bone, and joint: 9 (20.0%) ,Head and neck: 2 (4.4%)

Table 3: SSI Distribution by Type of Surgery

Type of Surgery	Total Cases (n = 360)	No. of SSI
Abdominal surgeries	150	24
Orthopedic surgeries	102	10
Pelvic & urogenital	68	8
Breast & axilla	18	2
Neurosurgery	22	1

Out of a total of 360 surgical operations, 253 were elective procedures, and the remaining 107 were emergency surgeries. A higher prevalence of SSI was observed among elective surgical procedures (85.5%) compared to emergency procedures (14.5%).Out of the 45 SSI cases, 24 (53.3%) were deep surgical site infections, 14 (31.1%) were superficial space SSIs, and 7 (15.5%) were organ-space infections.

Statistical analysis results showed that the following factors had a significant association with SSI rates (*p*-value ≤ 0.05), as shown in Table 3 Type of wound (*p*-value = 0.0001) Duration of surgery >2 hours (*p*-value = 0.031) Diabetes (*p*-value = 0.027) Prolonged hospital stay >7 days (*p*-value = 0.0001)

Table 4: Significant Risk Factors for SSI

Risk Factor	p-value
Type of wound	0.0001
Duration of surgery >2 hours	0.031
Diabetes	0.027
Prolonged hospital stay >7 days	0.0001

Table 4: SSI Distribution by Infection Depth

Type of SSI	No. of Cases (n = 45)	% of Total SSI
Deep surgical site infections	24	53.3%
Superficial SSIs	14	31.1%
Organ-space infections	7	15.5%

Table 5: Elective vs. Emergency Surgery and SSI Cases

Type of Surgery	Total Cases	SSI Cases	% SSI
Elective	253	38	85.5%
Emergency	107	7	14.5%

Antibiotic Resistance Profile

Table 6: summary of antibiotic resistance patterns observed in bacterial isolates from SSI cases:

Bacterial Isolate	Number of Cases	Resistance to Common Antibiotics
Staphylococcus aureus	12	Methicillin, Vancomycin (partially)
Escherichia coli	10	Ciprofloxacin, Ceftriaxone
Pseudomonas aeruginosa	8	Carbapenems, Aminoglycosides
Klebsiella pneumoniae	9	Beta-lactams, Carbapenems
Enterococcus spp.	6	Vancomycin (VRE)

Table 9: SSI Cases by Hospital Stay Duration

Hospital Stay Duration	Total Cases	SSI Cases	% SSI
<7 days	250	12	4.8%
>7 days	110	33	30.0%

DISCUSSION

Our study highlights a significant prevalence of SSI (12.5%) among surgical patients. The findings suggest that gender was not a significant risk factor for SSI, as both male and female patients had comparable infection rates. Age-wise, the highest prevalence was observed in the 35-60 years group, emphasizing the need for focused preventive measures in middle-aged patients.[17]

The type of surgery played a crucial role in SSI occurrence, with abdominal surgeries being the most affected. This aligns with previous studies, as abdominal procedures involve greater tissue manipulation and exposure, increasing the infection risk. Prolonged hospital stays (>7 days) and surgeries lasting more than 2 hours were significantly associated with higher SSI rates, suggesting that careful postoperative monitoring and timely discharge strategies may help reduce infection risks.[18]

Antibiotic resistance among SSI cases remains a growing concern, with pathogens such as Staphylococcus aureus and Escherichia coli exhibiting resistance to multiple antibiotics. This emphasizes the need for stringent antimicrobial stewardship programs and judicious antibiotic use in surgical patients.[19]

Overall, our findings underscore the importance of infection control measures, proper surgical techniques, and patient-specific risk assessment in minimizing SSI occurrences. Future research should explore targeted interventions to reduce the burden of SSI in high-risk populations.[20]

In this hospital, a single dose of 1gram ceftriaxone intravenous with or without 500 milligram Metronidazole intravenous (depending on the need for anaerobic coverage, especially in colorectal surgery) is given up to an hour before the procedure. However, the recommended dosage is 1 gram for metronidazole while 2 gram in the case of ceftriaxone according to American society of health-system pharmacists (ASHP) guidelines. Administering a lower dose to that of the recommended amount, not only predisposes patients to infections but also contributes to the development of resistance. 28 This shows that revaluation of antibiotics administered for prophylaxis may be needed.[21]

Most of the gram negatives showed better sensitivity to gentamycin as compared to other drugs, thus usage of the drug in the treatment of surgical site infection could be considered. The prevalence of MDR strains among isolates obtained from SSI in our study was comparable to other studies with the prevalence of MDR strains obtained from SSI ranging from as 66% to 85%. 30 This shows that there is a high prevalence of MDR strains in isolates from SSI which could be explained by the fact that these infections occur in a hospital setting where there is frequent exposure to antibiotics.[22]

There was a higher prevalence of MDR strains among gram negatives amounting to 81 % while MDR strains accounted for 68.8% of gram positives.[23] The higher prevalence of MDR strains among gram negatives was reflected in most of the studies reviewed that reported gram reaction among MDR strains with a prevalence of MDR strains among gram negatives ranging from 61% to 97%.[24]

CONCLUSION

SSI is still a major problem in postoperative patients in the study site. There was an alarming MDR rate of 86% among the bacterial isolates and high resistance to the commonly used antibiotics. We strongly recommend that antibiotic therapy should be guided by antimicrobial susceptibility patterns. We recommend surveillance of SSIs periodically including incidence, aetiology, antibiotic susceptibility profile and source of infection. We suggest a preoperative rectal swab to detect colonization with MDR bacteria in order to isolate affected patients and avoid wasteful usage of antibiotics. Finally, we recommend strict adherence to good sanitation practice including thorough hand washing, disinfection of inanimate objects and other infection control measures so as to minimize the spread of MDR strains of bacteria.

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