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Antibiotic Resistance Pattern of Surgical Site Infections at Surgery Outpatient Department of a Tertiary Care Hospital

Roksana Reza[1*] Mayin Uddin Mahmud[2] Sefa Sarwath Alam[3]
Md Mashud Rana[4] Shahidul Huq[5]

Abstract

Background: Surgical Site Infection (SSI) is one of the most common healthcare-associated infections, with significant morbidity, death and economic consequences. Antibiotic resistance is a growing problem nowadays, affecting SSI management and its control. This study aims to identify the bacterial profile, antimicrobial susceptibility and resistance pattern of SSI patients at Chittagong Medical College Hospital, Chattogram, Bangladesh.

Materials and methods: This cross-sectional study was conducted in the Surgery Outpatient Department of Chittagong Medical College Hospital. 137 wound swabs on a sterile cotton swab were collected from the surgical wounds of the patients and were processed following standard laboratory techniques. The identification of every individual bacterium was conducted by assessing colony features, gram stain, conventional biochemical assays, and antibiotic susceptibility testing using the disc diffusion technique.

Results: The study found that 88.3% of patients were found culture positive and 11 types of organisms were identified, with 62.8% showing Gram-negative organisms and 25.5% showing Gram-positive organisms. The frequency of commonly occurring different isolated bacteria revealed the presence of Pseudomonas bacteria in 31% cases, Staph. aureus in 17% cases and E. coli in 16%. A statistically significant association with antibiotic resistance was found regarding not maintenance of proper antibiotic dose and duration, history of indiscriminate antibiotic intake and irregular wound dressing after surgery ($p<0.05$).

Conclusion: A high prevalence of gram-negative organism infection was noted in SSI patients, with most commonly identified bacteria showing resistance to commonly used antibiotics. An increased prevalence of antibiotic resistance is observed among patients with a history of taking irrational antibiotics.

Key words: Antibiotic resistance; Bacteria; Surgical site infection.

1. Lecturer of Pharmacology and Therapeutics
Chittagong Medical College, Chattogram.
2. Assistant Professor (CC) of Surgery
Chittagong Medical College, Chattogram.
3. Professor of Pharmacology and Therapeutics
Chittagong Medical College, Chattogram.
4. Assistant Professor of Pharmacology and Therapeutics
Chittagong Medical College, Chattogram.
5. Associate Professor of Surgery
Chittagong Medical College, Chattogram.

***Correspondence: Dr. Mayin Uddin Mahmud**
Cell : 01712 05 53 98
E-mail: dr.mayin@gmail.com

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Introduction

Surgical Site Infections (SSI) rank as the third most commonly reported nosocomial infection, including roughly 25% of all nosocomial infections.[1] Surgical Site Infection (SSI) is an infection that happens at or close to the surgical incision within 30 days of surgery (Or one year in the case of organ/space infections with an implant in place). It can affect the skin, subcutaneous tissues, deep layers or distant organs and is characterized by either purulent drainage or the presence of organisms isolated from the wound site.[2] SSI is categorized into three types: superficial incisional, deep incisional, and organ/space SSI.[3]

SSIs contribute to antibiotic resistance which further leads to life-threatening morbidity. It also increases hospital stays and the cost of healthcare services. Besides, it increases the patient's economic burden and impairs their quality of life.[4] Moreover, according to the CDC report, SSI caused 3% of deaths worldwide in 2015.[2]

The factors associated with bacterial resistance include excessive prescribing of antibiotics, incomplete antibiotic courses by patients, excessive use of antibiotics in livestock and fish aquaculture, inadequate infection control in healthcare facilities, and substandard hygiene and sanitation practices.[5] The predominant bacterial pathogens identified in SSIs include Staphylococcus aureus, Coagulase-Negative Staphylococcus (CoNS) Acinetobacter spp, Pseudomonas spp, Escherichia coli, Klebsiella spp, Proteus spp, Enterobacter spp, Citrobacter spp, as well as anaerobic bacteria such as Clostridium spp. and Peptostreptococcus spp.[6]

The acquisition of antibiotic resistance mechanisms by these bacterial strains has highlighted challenges for managing SSIs worldwide. These challenges have been made even more significant by Methicillin-Resistant Staphylococcus Aureus (MRSA) Extended-Spectrum Beta-Lactamases (ESBL) producing Enterobacteriaceae and the involvement of polymicrobial flora and fungi.[7] In recent years, gram-negative organisms have grown as a cause of severe infections in many hospitals.[8]

In many SSIs, the responsible pathogens originate from the patient's endogenous flora. The causative pathogen depends on the type of surgery. The type of causative microorganisms may vary from hospital to hospital and the development of SSIs highly depends on patient factors, wound type and drugs prescribed to the patients.[9]

Antimicrobial resistance occurs naturally when pathogenic agents adapt to being exposed to antimicrobials used in medicine, food animals, crop production, and disinfectants in farms and homes.[10] The efficacy of current antimicrobial drugs has diminished, resulting in increased challenges and costs in treating illnesses, as well as more difficulty in controlling epidemics. This has led to a significant increase in the number of people becoming sick and dying from infectious illnesses that were previously able to be treated, such as TB, malaria, acute respiratory infections, and diarrhoea.[11]

The resistance patterns of bacteria linked with SSI differ worldwide, based on factors such as geographical location, local disease patterns, and the specific methods used to test the susceptibility of the bacteria to antibiotics.[12,13] Bacterial resistance is a formidable obstacle and adds complexity to the management of SSI. Nevertheless, there have been few recent findings about the frequency and occurrence of antibiotic-resistant bacteria causing SSI, particularly in Bangladesh.[13,14] Furthermore, a separate study indicated that antibiotic resistance is extremely prevalent in Bangladesh, and there is a notable absence of monitoring. Resistance data were not accessible for the majority of the country, and there were insufficient studies on certain pathogens to evaluate their resistance patterns.[15] As a result of these insufficient SSI monitoring programs, healthcare centers are unable to get accurate information about bacteria that have developed resistance to antimicrobial medicines. Contemplating this background, this research aims to assess the bacterial profile and antimicrobial resistance patterns in SSI patients at a tertiary hospital in Bangladesh.

Resistance patterns of SSI-associated bacteria vary globally, depending on the region, local epidemiology reports and susceptibility testing methodology.[12,13] Bacterial resistance poses a challenge and it complicates the SSI treatment. However, there were limited recent reports on the prevalence and incidence of resistant bacteria causing SSI, especially from Bangladesh.[13,14] Moreover, another study reported that the prevalence of antibiotic resistance is very high in Bangladesh and there is a significant lack of surveillance; resistance data were not available for most parts of the country and the number of studies for some pathogens was too few to assess their resistance patterns.[15] Due to these inadequate SSI surveillance programs, healthcare centers cannot obtain proper updates on bacteria resistant to antimicrobial drugs. Contemplating this background, this study aims to assess the bacterial profile and antimicrobial resistance patterns in SSI patients at a tertiary hospital in Bangladesh.

Materials and methods

This cross-sectional study was conducted in the Surgery Outpatient Department of Chittagong Medical College Hospital (CMCH) Chattogram, Bangladesh from March 2022 to February 2023. Adult male and female patients aged more than 18 years old with SSIs who attended the surgery Outpatient Department of CMCH were included in this study. Patients having prosthetic surgery, patients with uncontrolled diabetes mellitus and patients on steroid or anticancer drugs or other immunosuppressive drugs were excluded. Eligible patients were asked to provide voluntary informed consent for participation in the study. 140 patients with SSIs were conveniently screened and 137 patients were included in the study according to selection criteria. Socio-demographic and clinical data were obtained from the patient's medical record, interviewing and physical examination using the case record form. Variables are age, gender, educational status, socioeconomic condition, comorbidity, type of SSI, nature of surgery, type of surgical wound, pattern of bacterial growth, frequency of bacterial growth and sensitivity and resistance pattern of isolated bacteria to different antibiotics. When a clinical SSI was identified, a sterile cotton swab was used to acquire a sample from the patient's wound in a sterile manner. Every sample was marked with the date of collection, the method of collection and the patient's information. The swab was promptly immersed into a sterile tube containing a transport medium (Amies, Beckton Dickinson) and promptly transported to the microbiology department of the hospital for culture and sensitivity testing. After 24 hours, the cultured plates were inspected, and the results of the samples' sensitivity tests and culture were gathered. The Clinical and Laboratory Standards Institute's (CLSI) criteria were followed in the interpretation of the data. Modified Kirby-Bauer disc diffusion technique was used to assess the isolates' susceptibility to antibiotics according to CLSI guidelines. The organisms were classified as sensitive or resistant using established criteria after the zones of inhibition were assessed. Organisms were recognized by established procedures such as colony morphology, gram staining and relevant biochemical testing. Data were recorded in the form of an Excel worksheet. After completion of data collection, they were fed into SPSS for processing analysis. Data were presented by an appropriate method by frequency table in a simplified, self-explanatory and informative manner. The protocol was approved by the Ethical Review Committee, Chittagong Medical College, Chattogram, Bangladesh Ethical ID: Memo no. CMC/PG/2022/823; Date: 16/03/2022.

Results

Total 140 patients with wound infection were conveniently screened and 137 patients were included in the study according to selection criteria. Wound swab on a sterile cotton swab from the surgical wounds were collected from the patients.11 isolated bacteria were identified based on colony characteristics, gram stain, standard biochemical tests and antibiotic susceptibility testing with the disc diffusion method.

The mean ± SD age of the patients was 40.14 ± 18.99 years (Range: 18-70) years. Among 137 patients, 83 (60.6%) were male and 54 (39.4%) were female. Educational qualification represents, 42 (30.7%) patients had below primary education and 31 (22.6%) patients were educated up to primary level. 32 patients (23.4%) were homemaker and 24 patients (17.5%) were businessmen. 78 (56.9%) patient's place of residence was rural (Table I).

107 patients (78.1%) in our study had undergone emergency surgery. 55 patients (40.1%) had dirty type of wounds. 61 patients (44.5%) had superficial SSIs and 55 patients (40.1%) had deep SSIs. 91 patients (66.4%) had done regular wound dressing. After surgery, 97 patients (70.8%) had completed their antibiotic course, 83 patients (60.6%) had maintained the antibiotic dose and dosing interval properly and 43 patients (31.4%) had a history of indiscriminate antibiotic intake without prescription (Table II).

In our study total 11 bacteria were isolated. Pseudomonas was the most frequently encountered bacteria 43 (31%) followed by Staph aureus (23 in number, 17%) and E. coli (22 in number, 16%). 16 cases (12%) had no growth (Figure I). Gram positive bacteria (Different species of Staphylococcus) showed variable resistant to antibiotics. Benzylpenicillin, Ciprofloxacin, Levofloxacin, Erythromycin and Co-trimoxazole were resistant towards most of these Staphylococcus. Ceftriaxone and Ampicillin were mostly sensitive to Staphylococcus (Table III). There was a variable resistant pattern of common antibiotics towards gram negative bacteria. Less resistance was observed to Meropenam, Levofloxacin, Gentamicin, and Ciprofloxacin. Azithromycin, Cefixime, Ceftazidime, and Ceftriaxone showed resistance towards common gram negative bacteria (Table IV).

Logistic regression analysis was done for the association of gender, type of wound, history of wound dressing, antibiotic course completed after surgery, maintenance of proper antibiotic doseand dosing interval and history of indiscriminate antibiotic intaketo antibiotic resistance (Table V). A statistically significant association was found regarding history of irregular wound dressing, not maintaining antibiotic dose and dosing interval and history of indiscriminate antibiotic intake without prescription ($p<0.05$).

Table I Socio-demographic profile of the study population (n=137)

Age (Years)	Mean ± SD	Range
	40.14 ± 18.99	18-70
Sex	Frequency	Percentage
Female	54	39.4
Male	83	60.6
Educational qualification		
Below primary	42	30.7
Up to primary	31	22.6
Up to SSC	21	15.3
Up to HSC	24	17.5
Graduate and above	19	13.9
Occupation		
Business	24	17.5
Service	16	11.7
Laborer	21	15.3
Farmer	13	9.5
Home maker	32	23.4
Student	19	13.9
Others	12	8.8
Residence		
Rural	78	56.9
Urban	59	43.1

SD: Standard Deviation, SSC: Secondary School Certificate, HSC: Higher Secondary School Certificate.

Table II Clinical profile of the study population (n=137)

Variables	Frequency	Percentage (%)
Nature of Surgery		
Elective	30	21.9
Emergency	107	78.1
Type of wound		
Clean	29	21.2
Clean contaminated	29	21.2
Contaminated	24	17.5
Dirty	55	40.1
H/O wound dressing		
Done	91	66.4
Not done	46	33.6
Type of SSI		
Superficial	61	44.5
Deep	55	40.1
Organ space	21	15.3
Antibiotic course completed after surgery		
Yes	97	70.8
No	40	29.2
Proper maintenance of Antibiotic dose and dosing interval		
Yes	83	60.6
H/O indiscriminate Antibiotic intake without prescription		
Yes	43	31.4
No	94	68.6

SSI: Surgical Site Infection.

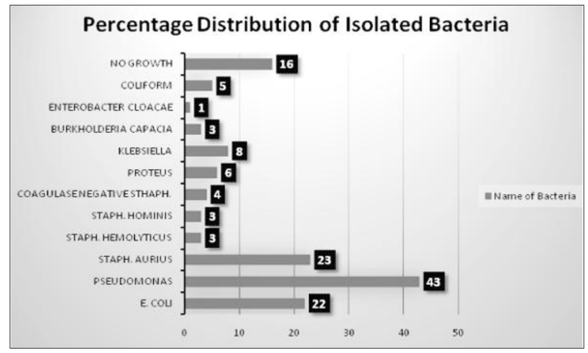

Figure 1 Percentage distribution of the isolated bacteria found in culture report (n= 137)

Table III Resistance patternof antibiotics used against Gram-positive bacteria

Antimicrobial agents	Staph. aureus	Staph. hemolyticus	Staph. hominis
Benzylpenicillin	8.7%	100%	100%
Ampicillin	69.6%	---	33.3%
Ciprofloxacin	60.8%	100%	33.3%
Levofloxacin	8.7%	100%	33.3%
Erythromycin	39.1%	100%	100%
Ceftriaxone	4.3%	---	---
Co-trimoxazole	56.5%	100%	33.3%

Table IV Resistance pattern of antibiotics used against Gram-negative bacteria

Antimicrobial agents	E.coli	Pseudomonas	Klebsiella	Proteus
Azithromycin	63.6%	20.9%	37.5%	100%
Co-trimoxazole	---	62.8%	50%	---
Cefixime	90.9%	46.5%	100%	---
Ceftazidime	63.6%	69.7%	50%	50%
Ceftriaxone	50%	30.2%	62.5%	---
Gentamicin	---	48.8%	---	---
Ciprofloxacin	9.1%	32.5%	---	---
Levofloxacin	9.1%	25.5%	---	---
Meropenem	---	30.2%	---	---

Table V Logistic regression analysis of factors associated with antibiotic resistance

Variables	Odds ratio	95% CI		p value
		Lower	Upper	
Gender	0.091	-0.081	0.262	0.288 (ns)
Type of wound	-0.005	-0.156	0.147	0.951 (ns)
H/O irregular wound dressing	1.035	0.818	1.288	0.039 (s)
Antibiotic course completed after surgery	0.814	0.706	0.939	0.072 (ns)
Not maintaining Antibiotic dose and dosing interval	1.271	1.067	1.546	0.014 (s)
H/O indiscriminate Antibioticintake without prescription	1.333	1.092	1.629	0.006 (s)

OR: Odds Ratio, CI: Confidence Interval.
- ns= non-significant, s=significant.
- p value derived from Chi-square test.

Discussion

Surgical Site Infection (SSI) is the most often reported surgical complication and a common healthcare-associated infection worldwide.[16] Management of SSIs is challenging due to an increasing pattern of antibiotic resistance by recognized bacterial pathogens. The issue is more severe in nations with inadequate resources where rational antibiotic usage is seriously impaired.[17]

In this study, mean ± SD age of the patients was 40.14 ± 18.99 years (Range: 18-70) years with a male dominance (60.6%). Similar findings were reported by Roopashree et al. where participants were 41-60 years old (45.63%).[18] In another study it was found that mean ±SD age of the patients was 38±16.30 years with male predominance (59.4%).[16] But Abayneh et al. showed that mostof the patients were inthe age group 19–35 years.[19] This may be due to the difference in life expectancy of their study population.

Maximum patients (78.1%) had undergone emergency surgery in our study. 42.4% of patients had clean and clean-contaminated wounds and 40.1% of patients wound types were dirty.Abayneh et al. described similar findings where just over half of the participants (55.3%) had emergency surgery and 89.3% of patients had clean and clean-contaminated wounds.[19] Misha et al. also found more than two-thirds of surgical procedures were emergency.[16] Superficial and deep SSI was found in 61 (44.5%) and 55 (40.1%) patients respectively in our observation. While the majority of the clinical SSIs noted were deep incisional (50.6%) in the study by Hope et al. possibly that is due to differences in surgical procedures.[20] In this study, after surgery, 97 (70.8%) patients had completed their antibiotic course. 83 (60.6%) patients had maintained the antibiotic dose and dosing interval after surgery properly. History of indiscriminate antibiotic intake without prescriptionwas among 43 (31.4%) patients. A similar finding was also documented by Castro-Sánchez et al.[5]

In the present study,121 patients (88.3%) were culture positive and 16 patients (11.7%) did not show any growth in culture report. Negative culture reports may suggest multiple factors like wound infection other than bacterial infection, faulty or inadequate swab collection, wound skin condition etc. 86 patients (62.8%) staining showed Gram-negative organisms, 35 patients (25.5%) staining showed Gram-positive organisms. 11 types of bacteria were identified in the wound swab culture reports, with Pseudomonas (31%) being the most frequently identified organism followed by Staph. Aureus (17%) and E. Coli. (16%). In a recent research it was found that all patients with SSIs tested positive for bacterial cultures and a total of 41 bacterial isolates were identified.[19] Out of them, 73.2% were classified as Gram-negative bacteria, while 26.8% were classified as Gram-positive bacteria. Escherichia coli comprised 29.3% of the total, with Staphylococcus aureus accounting for 19.5%, Proteus species for 14.6% and Pseudomonas aeruginosa for 12.2%. Abosse et al. discovered that out of the 125 bacterial isolates, Staphylococcus aureus was the most prevalent, followed by Pseudomonas aeruginosa and Klebsiella species.[21] A separate study found that of 134 samples, 102 were positive for culture. Most of the samples consisted of Gram-negative bacteria. The most prevalent bacteria were E. coli (25.49%) followed by Klebsiella spp. (23.53%), Pseudomonas (14.71%) and Proteus (3.92%).[22] Other studies have reported similar outcomes.[1,16,20]

In our study, Gram-positive organisms revealed varying degrees of resistance (8.7%-100%) against various antibiotics. Among them Staph. Aureus shows resistance to all of them. Gram-negative organisms showed (9.1%-100%) resistance to commonly used antibiotics. Among them, Pseudomonas was resistant to all the mentioned antibiotics in different percentages. A similar observation was noted in the study by Abayneh et al. Gram-positive isolates of S. aureus showed higher resistance toward ampicillin (87.5%).[19] Furthermore, ceftriaxone, cefoxitin, gentamicin, ciprofloxacin, doxycycline, co-trimoxazole, and chloramphenicol were all resistant to Gram-negative isolates, with percentages ranging from 50% to 83.3%. Ampicillin was the drug against which the majority of resistance was shown (84.38%) according to another research.[20] A similar study mentioned about multi-drug resistance of Pseudomonas.[14] Though Ceftazidime, Cefixime, and Ampicillin are frequently used antibiotics in our country for wound infections, but according to our study we found them relatively higher resistant against commonly isolated organisms like Pseudomonas, E. coli, and Staph. aureus. Without a culture sensitivity report, we would discourage the use of these antibiotics since the resistance towards them has been on the rise.

Logistic regression analysis was done for the association of gender, type of wound, history of wound dressing, antibiotic course completion after surgery, maintenance of proper antibiotic dose and duration and history of taking an indiscriminate antibiotic with antibiotic resistance. A statistically significant association was found regarding history of irregular wound dressing, not maintenance of antibiotic dose and duration and history of indiscriminate antibiotic intake without prescription ($p<0.05$). Larson concluded that both behavioural and environmental/policy factors can contribute to the emergence of resistance within society.[23]

Limitations

The susceptibility pattern of bacterial isolates to commonly prescribed antibiotics might not be generalized globally. This is a single-centered study and sample size was small. So the results do not reflects the exact picture of the country.

Conclusion

Antibiotic resistance is a burden to health care services. In our study, 11 types of organisms were identified; among them gram-negative organisms were predominant. Pseudomonas, Staph. Aureus and E. Coli were the most commonly identified isolates. All of them showed high resistance against routinely used antibiotics against them. Nearly all of the isolates exhibited multidrug resistance which is alarming for bacterial infectious disease control at present and in the near future. To mitigate the impact of SSIs caused by antibiotic-resistant bacterial infections, it is essential to regularly monitor the bacterial profile, conduct antibiotic susceptibility testing, and enforce a stringent procedure for antibiotic administration and dispensing.

Recommendations

- A multicentered study is needed with a large sample.
- Formulation of infection control measures.
- Appropriate use of antibiotics must be considered compulsory to alleviate wound infection rates.
- Not to prescribe “Watch and Reserve Group” antibiotics frequently as they are last resort drugs for high resistance cases and when all other drugs fail.

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Contribution of authors

RR-Conception, acquisition of data, manuscript drafting & final approval.

MUM-Design, acquisition of data, data analysis, data interpretation, critical revision & final approval.

SSA-Conception, critical revision & final approval.

MR-Design, critical revision of content & final approval.

SH-Data analysis, manuscript drafting, critical revision & final approval.

Disclosure

All the authors declared no competing interest.

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