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Antibiogram of Pathogens Isolated from Surgical Site Infections at a Tertiary Care Hospital, Rawalpindi

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ABSTRACT

Background: Surgical site infections are the most commonly reported healthcare-associated infections. However, in developing nations, data regarding the antibiogram of pathogens isolated from these infections are scarce. **Objective:** This study aimed to assess the bacterial profile and antimicrobial susceptibility of isolates from surgical site infections in post-operative patients at a tertiary care hospital in Rawalpindi. **Study Design:** Retrospective observational study. **Settings:** Department of Microbiology, Pakistan Railway hospital (PRH), Rawalpindi Pakistan. **Duration:** January 2021 to December 2021. **Methods:** All specimens (301) with positive cultures were recruited from surgical wards. Following standard procedures, specimens were cultured; and data were retrieved from the hospital database. Pathogens were identified using laboratory techniques including Gram staining and biochemical tests, and the antibiotic sensitivity patterns were recorded. Antimicrobial susceptibility testing was performed according to the protocols of the Clinical & Laboratory Standards Institute CLSI, using the modified disk diffusion method. The data was analyzed using SPSS version 24.0. **Results:** A total of 1128 patient samples were found to be culture positive in study period, out of them 301 (27%) patients samples were with surgical site infections, cultures comprised both gram-positive (33%) and gram-negative organisms (65%), with a small portion (1-2%) of mixed microbial growth. *Escherichia coli* was the most prevalent gram-negative species 105(34.88%), followed by *Klebsiella pneumoniae 63*(21%). Appreciable resistance was observed against Penicillin, Cefotaxime, Ceftriaxone, and Carbapenems. **Conclusion:** Various gram-positive and gram-negative microorganisms, such as *E. coli, Klebsiella*, *Staphylococcus aureus*, *MRSA*, and *Pseudomonas*, are commonly found in surgical site infections. No antibiotics were universally effective; however, Penicillin, Ceftriaxone, Cefotaxime, and Quinolone resistance was observed.

Keywords: *Antimicrobial susceptibility, Bacterial isolates, Surgical site infections, Patient safety.*

INTRODUCTION

Surgical site infections (SSIs) contribute as a substantial concern in healthcare settings, representing a major complication associated with surgical procedures. [1] With an incidence rate ranging from 2% to 20%, SSIs contribute to prolonged hospital stays, increased morbidity, and mortality, placing a considerable strain on the patients and healthcare systems.[1] Surgical site infections (SSIs) are described as "infections that occur after surgery at the site of incision, organ, or space" by the Centers for Disease Control and Prevention (CDC).[2] In a study conducted in Pakistan, it was found that four out of nine elderly patients developed SSIs, underscoring the prevalence and impact of these infections.[3] The occurrence of SSIs is influenced by a combination of factors, including wound site contamination, microbial pathogenicity, and the host's immune response.[4] These infections can manifest either during the surgical procedure (primary wound infection) or postoperatively (secondary wound infection).[5] Numerous endogenous factors, including the age of the patient, their weight, co-morbidity, and immunological status, along with exogenous factors like pre-operative prophylactic measures, pre-operative hospitalization, surgical and wound type, and sterilization of equipment, contribute to their development.[6]

Despite advancements in the prevention of infection and control practices for SSIs, for example enhanced ventilation in operating theaters, sterilization techniques, and the availability of prophylactic antibiotics, SSIs remain a significant challenge.[7] The proliferation of microbes including *Staphylococcus aureus*, Methicillin-resistant *Staphylococcus aureus* (MRSA), *Escherichia coli*, and *Klebsiella* species among others, contribute to the persistence of SSIs in hospital settings.[8] The patterns of resistance exhibited by these SSI-related pathogens vary globally, influenced by regional factors, local epidemiology reports, and susceptibility testing methodologies.[9] Notably, over 70% of isolates causing hospital-acquired infections demonstrate resistance to at least one commonly used antibiotic.[10] Additionally, the improper use of surgical prophylactic antibiotics has been linked with an increased risk of SSIs.[9] Therefore, proper selection, dosage, and duration of antimicrobial agents are crucial in reducing the incidence of these infections.[11]

Considering these challenges, it becomes imperative to identify the susceptibility patterns of pathogens towards various antibiotics. Thus, this study purposes to investigate the antibiogram of microorganisms isolated from surgical site infections at a tertiary care hospital, directing to provide valuable insights into the prevalence and resistance patterns of the causative pathogens. The results will facilitate the optimization of antibiotic therapy regimens, development of local treatment guidelines, and implementation of effective infection control measures. Ultimately, this research will contribute to the mitigation of SSIs and to improve patient outcomes in the context of surgical procedures.

METHODS

A retrospective study was conducted which encompassed the data obtained from Microbiology section of Pathology department at Pakistan Railway hospital (PRH), a tertiary care teaching hospital of Rawalpindi with the approval of Ethical Review Committee of Islamic International Dental College (Ref.No. IIDC/IRC/2023/004/001). A total of 301 positive cultures of microbial pathogens were obtained from different types of collected specimen. These positive cultures were selected to comment on their antibiotic sensitivity pattern.

Specimens with positive cultures from surgical patients (outdoor and admitted patients) including urine, pus, wound, blood, and others (tissue fluid, wound, and cannula tip etc.), irrespective of age and gender were included in the study.

Samples without culture growth and other than surgical ward and surgical OPD patients were excluded from the study.

All the samples were received before the wounds were cleaned with antiseptic or antibiotic therapy was started for their healing. Standard microbiological procedures like Gram staining, morphological examinations, and biochemical evaluation were conducted for bacterial isolation, their identification and evaluation of their drug susceptibility. Typical biochemical tests were performed, in accordance with the standard guidelines, to identify the species of the isolates from pure colonies. The antibiotics (drugs) disks tested for susceptibility for both gram-negative and gram-positive bacteria; and were placed on the agar with minimum 20 mm spacing and incubated at 37 °C for one day. Following this, zones of inhibition were measured, recorded, and the strains were classified as "resistant," "intermediate," or "sensitive" according to CLSI guidelines.[12]

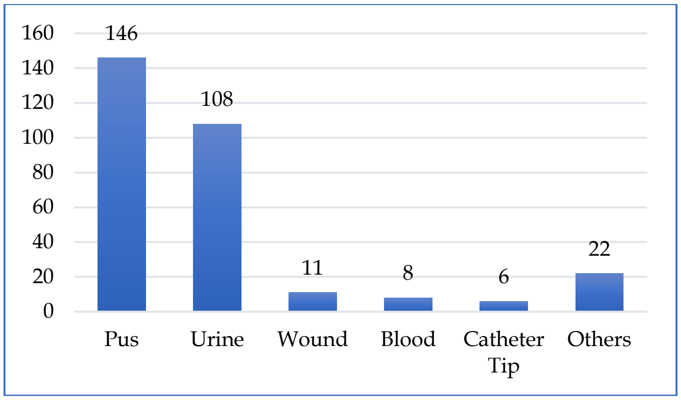
An Antibiogram encompassing the use of antibiotics discs including Ampicillin (AMP 10 µg), Amoxicillin/Clavulanic acid (AMC 20/10 µg), Amikacin (AK 30 µg), Azithromycin (15 µg), Aztreonam (30 µg), Cefotaxime (CTX 30 µg), Ceftazidime (CAZ 30 µg), Ceftriaxone (CRO 30 µg), Ciprofloxacin (CIP 5 ug), Cefuroxime (30 µg), Trimethoprim/Sulfamethoxazole (1.25/23.75 µg), Cloxacillin (CLOX 5 µg), Vancomycin (VAN 30 µg), Erythromycin (E 10 µg), Imipenem (IPM 10 µg), Penicillin (10 µg), Ofloxacin (5 µg), Gentamicin (CN 10 µg), Tetracycline (TET, 30 µg), Fosfomycin (FOX 50 µg), and Nitrofurantoin (F 300 µg), Clindamycin (DA, 15 µg), Meropenem (MEM 10 µg), Chloramphenicol (C, 30 µg).

The data was analyzed using Statistical Package for the social sciences (SPSS) version 24.0. Qualitative variables (the patient's gender, nature of samples, organisms secluded, ward, and antimicrobial susceptibility.) were explained by descriptive statistics (frequencies, percentages), whereas Mean ± SD (standard deviation) were calculated for descriptive numerical (continuous) variables of age (years).

RESULTS

In the time between January and December 2021, the Microbiology Lab received a total of 1128 patient samples that tested positive for culture. After applying inclusion and exclusion criteria, 301 (27%) of these samples were identified as originating from patients with infections acquired in surgical wards. Among these patients, 159 (53%) were female and 142 (47%) were male, with a mean age of 48 ± 18.45 years. Out of the total, 162 (54%) were outpatient cases, while 139 (46%) were admitted with surgery-related infections. The specimens collected from surgical patients included 146 pus samples, 108 urine samples, 11 wound samples, 8 blood samples, 6 catheter tip samples, and 22 samples of other types (Figure 1). Their percentage distribution is shown in table 1.

Figure 1: Category of specimens from surgical ward patients (n=301)



From patients who developed SSI (n = 301) revealed growth of microbial pathogens consisting of both gram positive (33%) and gram-negative organisms (65%). In addition, 1-2% were a mixture of two microbial growths. Amongst the various types of bacteria identified, Escherichia coli was found to be the most recurrently found gram negative bacteria 105 (21.43%), followed by Klebsiella pneumoniae 63 (21%). The detailed percentages of all isolated pathogens have been shared in Table 1.

Table 1: Categories of microbial pathogens

Organism Name	Number	Percentages
Escherichia coli	105	34.88%
Klebsiella	63	21%
Staphylococcus aureus/MSSA	43	14%
MRSA	29	9.60%
Pseudomonas	14	4.60%
Proteus species	9	2.90%
Enterococcus	8	2.60%
Acinetobacter	8	2.60%
Shigella species	7	2.30%
Providencia stuartii	6	1.90%
Streptococcus	5	1.60%
Burkholderia	4	1.30%

Our study results present the diverse resistance patterns exhibited by microorganisms cultured from SSI wounds specimens. According to the findings, Escherichia coli, the most frequently isolated organism, demonstrates high sensitivity to Cefoperazone, followed by Cefotaxime and Amoxicillin/Clavulanic acid. The second most common gram-negative organism, Klebsiella, shows susceptibility to numerous antimicrobials except for Penicillin, Ciprofloxacin, and Cefotaxime. Pseudomonas aeruginosa displays resistance against Cefotaxime, Ceftriaxone, COT/SXT, Chloramphenicol, and Vancomycin. In contrast, Gram-positive pathogens Staphylococcus aureus and MRSA exhibit resistance to Penicillin's (AMP & AMC), Cefotaxime, Ceftriaxone, COT/SXT, Chloramphenicol, and Fosfomycin. The detailed resistance pattern of the most frequently isolated pathogen is shown in Table 2, 3 and their comparison in Figure 2.

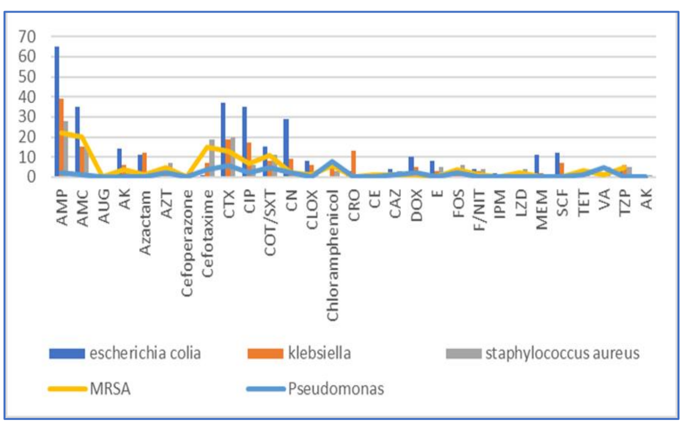
Table 2: Resistance pattern of gram-positive micro-organisms to different antibiotics

Drugs	Gram positive Pathogen	
	Staphylococcus aureus (MSSA) (n=43)	***MRSA* (n=29)**
AMP	28 (65%)	22 (76%)
AMC	15 (35%)	20 (69%)
AK	2 (5%)	4 (14%)
ATM	1 (2%)	1 (3%)
AZT	7 (16%)	5 (17%)
CPZ	-	-
CFT	19 (44%)	15 (52%)
CTX	20 (47%)	13 (45%)
CIP	6 (14%)	7 (24%)
COT/SXT	11 (26%)	11 (38%)
CN	2 (5%)	2 (7%)
CLOX	2 (5%)	1 (3%)
C	3 (7%)	6 (21%)
CRO	-	-
CE	2 (5%)	1 (3%)
CAZ	3 (7%)	1 (3%)
DOX	-	1 (3%)
E	5 (12%)	-
FOS	6 (14%)	4 (14%)
F/NIT	4 (9%)	1 (3%)
IPM	-	-
LZD	4 (9%)	2 (7%)
MEM	-	-
SCF	-	-
TET	2 (5%)	3 (10%)
VA	5 (12%)	1 (3%)
TZP	5 (12%)	5 (17%)

Table 3: Resistance pattern of gram-negative micro-organisms to different antibiotics

Drugs	Gram Negative Pathogen		
	Escherichia coli (n=105)	*Klebsiella* (n=63)	*Pseudomonas* (n=14)
AMP	65(61.90%)	39 (62%)	2(14%)
AMC	35 (33.33%)	15(24%)	1(7%)
AK	14(13.33)	6(10%)	-
ATM	11(10.47%)	12(19%)	-
AZT	2 (1.9%)	1(2%)	2(14%)
CPZ	-	-	-
CFT	1(0.95%)	7(11%)	4(29%)
CTX	37 (35.24%)	19(30%)	6(43%)
CIP	35(33.33%)	17(27%)	2(14%)
COT/SXT	15(14.28%)	8(13%)	5(36%)
CN	29 (27.61%)	9(14%)	2(14%)
CLOX	8 (7.6%)	6(10%)	-
C	-	6(10%)	8(57%)
CRO	3 (2.85%)	13(21%)	-
CE	-	2(3%)	-
CAZ	4 (3.80%)	2(3%)	1(7%)
DOX	10 (9.52 %)	5(8%)	2(14%)
E	8 (7.6%)	3(5%)	-
FOS	1 (0.95%)	1(2%)	2(14%)
F/NIT	4 (3.80%)	3(5%)	-
IPM	2 (1.9%)	1(2%)	-
MEM	11(10.47%)	2(3%)	-
SCF	12 (11.42 %)	7(11%)	-
TET	-	-	1(7%)
TZP	3 (2.85%)	6(10%)	-

Figure 2: Comparison of resistance pattern of Microbial pathogens from SSI Specimens



DISCUSSION

Postoperative surgical site infections (SSIs) continue to pose a substantial burden on patients undergoing surgical procedures, resulting in increased morbidity. This results in elevated healthcare costs due to prolonged stays at the hospital, heightened necessity for nursing care, further wound management, potential readmissions, and additional surgical interventions.[14] Accurate identification of bacterial microbes and the selection of appropriate antibiotics are crucial for effectively managing these infections. In our study, the overall rate of positive cultures from patients with surgical site infections was found to be 27% that is very close to the findings of Gebissa *et al*., *and* Sattar *et al*., from Abbottabad who reported prevalence of SSI was 23.3% & 33.68% respectively.[14] On the contrary, our infection rate is lower compared to the reported rate of 71.7% in India but higher than those observed in various other countries.[2,14] For instance, the incidence of SSIs is 4.4% in Taiwan, 7.5% in the United States, 5.2% in Japan, and 6.23% in Peshawar.[15] In the present study there is predominance of *Escherichia coli* (34.80%) and *Klebsiella pneumoniae* (21%) that are comparable with the study of Kochhal *et al*., carried out at India .[14] Similarly, majority of the local studies have showed the predominance of gram negative microorganisms in comparison with the Gram-positive growth.[16] Moreover these findings are in contrast to studies conducted in the different areas of Pakistan that reveal the incidence of SSI in different provinces ranges from 5.78% to 17.5%.[2] In addition, Sundus *et al*., at Rawalpindi reported commonly isolated pathogens as *Staphylococcus aureus* (21.09%), Methicillin Resistant *Staphylococcus aureus* (MRSA) (20.31%), *Escherichia coli* (18.75%) and *Pseudomonas aeruginosa* (14.06%).[17] These differences may be due to study populations, patients care, infection control measures and hygienic practices. The difference in the magnitude of surgical site infections may be attributed to the environmental factors, the surgical setup, and the type of procedures.

The isolation rate of Gram-negative bacteria, in our study, was greater (70.76%) as compared to gram positive bacteria (29.23%). This finding is in accordance with a study conducted at Ethopia which revealed Gram negative bacteria to be (78%) rather than, Gram-positive bacteria (11.5%).[10] The relation of gram negative bacteria with intra-abdominal surgeries, as reported previously in the literature, may contribute to be the reason for its predominance, as majority of the infected patients were associated with abdominal surgery.[18] In this study, the most encountered pathogen, *Escherichia coli*, displayed resistance rates of 35.24% to Ceftriaxone, 61.90% to Ampicillin, 33.83% to Ciprofloxacin, and 27.61% to Gentamicin, which contrasts with the findings of Misha *et al*. Additionally, the current study revealed that gram-positive pathogens exhibited increased resistance to Ampicillin (76%), SXT/Cot (38%), and Cefotaxime (52%).[9] These results are generally aligned with the findings of the study conducted by Sundus *et al*., who observed that the most of the gram-negative bacteria were highly resistant to Ampicillin and Ceftazidime (91.67% each), Cefotaxime (75%), Chloramphenicol, and Ciprofloxacin (62.50% each), while gram-positive bacteria showed resistance to Penicillin, Amikacin, Imipenem, and Cefotaxime.[17] These high rates, particularly in the emergency surgeries, could be attributed to the lack of human resources, infrastructure, poor sanitation, contaminated water, overcrowding, and frequently a lack of interest in the infection control by health care staff.[19]

Klebsiella pneumoniae the second commonest microbe in our patients, observed resistance against Ampicillin (62%), CTX (30%) and Ciprofloxacin (27%) and sensitivity against Gentamicin, Meropenem, and Nitrofurantoin. These findings are in line with a previous study in the same city that exposed increased sensitivity against Gentamicin and Imipenem.[17] Moreover in present study *Klebsiella* species revealed less resistance to Ceftazidime (3%) and Gentamicin (14%). These facts are in accordance with Roy *et al*., who strongly supports that Gentamicin is a suitable antibiotic in *Klebsiella* infection.[20]The third most frequently identified pathogen was *Pseudomonas aeruginosa*, demonstrating resistance to Chloramphenicol (57%), Cefotaxime (29%), Ceftriaxone (43%), COT/SXT (36%), and Gentamicin (14%). These findings are in comparison to WHO data, reporting that antimicrobial resistance rates of *P. aeruginosa* to Fluoroquinolones, Ceftazidime, and Aminoglycosides in 2020 were 46.4%, 41.0%, and 37.1%, respectively.[21] Moreover, in this study, *Pseudomonas aeruginosa* exhibited full susceptibility to Carbapenems, which contrasts with findings from an Egyptian study where 28.57% resistance was observed in surgical site infections.[22] This underscores the notion that the susceptibility of *P. aeruginosa* to Carbapenems varies significantly based on geographical distribution.

Among the Gram-positive microbial pathogens, the most isolated organisms from our samples were *Staphylococcus aureus* (14.2%) and MRSA (9.6%). These findings closely align with a study conducted in Iran, which found that surgical wound swabs from surgical wards yielded bacterial pathogens, with 16.6% identified as *S. aureus* and a higher prevalence of MRSA (83%) compared to our study.[23] In contrast, our study results diverge from another study commenting on three years data, which reported higher rates of *Staphylococcus aureus* (34.93%) and MRSA isolated from male patients (62.54%) and female patients (37.45%) with surgical site infections[8]. The *Staphylococcus aureus* and MRSA isolated in our study exhibited resistance to Penicillin, COT/SXT, Imipenem, Ceftriaxone, and Cefotaxime, which supports the observed high resistance pattern of these pathogens reported by Sundus *et al*., and Narula *et al*. in their study conducted in Rawalpindi.[17,24] Based on our understanding, Cephalosporins and Carbapenems are regarded as effective antibiotics. In our investigation, the general resistance profile to commonly utilized antibiotics appears to be lower compared to prior studies conducted in various countries, including Pakistan. However, the increasing resistance to these frequently prescribed antimicrobials is concerning. These findings strongly advocate for collaborative initiatives in these domains to mitigate the occurrence of surgical site infections (SSI).

CONCLUSION

Gram-negative and gram-positive organisms have been recognized as causal agents in surgical site infections. Despite the lower resistance rates observed in our study for commonly used antibiotics in treating such infections, the rise in resistance to Penicillin, Cefotaxime, and Quinolones remains a cause for concern. It is advised to utilize antibiotics judiciously in accordance with the hospital antibiogram or antimicrobial guidelines, which should be regularly updated to reduce the occurrence of Surgical Site Infections. Greater focus is required within Pakistani hospitals to mitigate infection rates following surgical procedures. A multitude of multicenter studies are essential to ascertain the precise incidence of Surgical Site Infections (SSIs) at the national level in Pakistan. Patient education and awareness are pivotal factors in addressing the incidence of SSIs in Pakistan. Consequently, surgeons and surgical teams can play a crucial role in assisting patients in preventing the occurrence of SSIs.

LIMITATIONS

Apart from its strengths, the presented study carries various limitations. Primarily, it was conducted exclusively at a single tertiary care hospital, possibly constraining the applicability of its results nationwide. Additionally, both the study's duration and sample size are relatively modest. It's noteworthy that the study solely concentrated on general surgical wards.

Tackling surgical infections demands worldwide strategies and holistic approaches, considering their extensive ramifications. This entails bolstering tools and methodologies for source management, instituting rigorous surveillance initiatives, and prioritizing antibiotic stewardship, infection control, and preventive measures to address antimicrobial resistance (AMR).

SUGGESTIONS / RECOMMENDATIONS

Strengthening antibiotic stewardship programs within hospitals are needed to ensure the judicious use of antibiotics, specifically targeting the prevention and treatment of surgical site infections (SSIs). Regular training and audits can enhance adherence to these programs. Advocate medical practitioner for the formulation and implementation of national policies aimed at reducing SSIs and antibiotic resistance. This can include guidelines for surgical practices and antibiotic use.

CONFLICT OF INTEREST / DISCLOSURE

The authors declare no conflict of interest.

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