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Postoperative Surgical Site Infections and Their Antimicrobial Resistance Patterns Among Patients at The Yaoundé Central Hospital

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1. Abstract

1.1. Background

Unrestrained and rapidly spreading antimicrobial resistance (AMR) among bacterial populations has made the management and treatment of postoperative wound infections a serious challenge in clinical practice. Surgical site infection (SSI) is the most common nosocomial infection in surgical patients and a significant source of postoperative morbidity and mortality. In this study, we aimed to establish antimicrobial patterns in patients with SSI after surgery in the Yaoundé Teaching Hospital.

1.3. Method

In this prospective cohort study, we employed a convenience sampling technique. Pus swab samples were collected from 24 selected patients admitted in the postoperative ward of the hospital, after undergoing surgery from February 9, 2021, to May 17, 2021.

1.4. Results

The prevalence of SSI was 10.67% (24/225). Of the 24 pus swabs collected, 70.8% were culture-positive and 8 species were isolated. The most common germ isolated was Staphylococcus aureus (29.6%), followed by Klebsiella spp, Escherichia coli, and Enterobacter cloacae. SSI was significantly associated with diabetes in the bivariate analysis (p, 0.016), with an ASA score > II (p, 0.03). Multi-drug resistance was seen among all bacterial isolates, especially to ceftriaxone (88.2%), cefuroxime (70.6%), and gentamicin (52.9%).

1.5. Conclusion

The prevalence of SSI was relatively high in our study (10.67%). The commonest isolated germ from SSIs was Staphylococcus aureus (29.3%). Multi-drug resistance was very common among the bacterial isolates, and the most sensitive antibiotic was amikacin (100%).

2. Introduction

Antimicrobial resistance (AMR) is a significant health and economic burden for the society, as it increases the threat of untreated bacterial infections [1]. Unrestrained and rapidly spreading AMR among bacterial populations has made the management and treatment of postoperative surgical site infections (SSIs) a serious challenge in clinical and surgical practice. Patients with postoperative SSIs are exposed to numerous microbes circulating in the hospital [2]. Most postoperative wound infections are hospital-acquired, vary from one hospital to the other, and are associated with complications [2]. Interventions of AMR containment in healthcare facilities have mostly been implemented in high-income countries. In low-and middle-income countries (LMICs), the burden of AMR is difficult to quantify since interventions require time and financial resources. Therefore, there is a persistent need to intervene [3].

In Cameroon, antibiotics (especially beta lactams, aminoglycosides, and sulfonamides) are used indiscriminately by some health personnel to manage wound infections. Furthermore, because antibiotics can easily be obtained as over-the-counter drugs from street vendors at a low cost, there is a tendency for patients to purchase and use them repeatedly and indiscriminately without medical supervision. This practice stems from the lack of knowledge of antibiotic resistance pattern and scarcity of data on the antimicrobial susceptibility profile of common

pathogens [4]. Surgical antibiotic prophylaxis (SAP) plays a pivotal role in the prevention of perioperative infection. The use of SAP remarkably increases the total amount of antibiotics used in hospitals and healthcare facilities and may be correlated to increases in AMR and healthcare costs. SAP is one of the most important factors for reducing the rate of surgical site infections. According to the World Health Organization, the incidence rate of SSI in LMICS ranges from 1.2 to 23.6% [3]. A bacteriological study of postoperative SSIs revealed that the main culprits for wound infection are bacteria, including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Klebsiella spp. Gram-positive bacteria were more predominant in the postoperative wound samples than Gram-negative bacteria. S. aureus and E. coli exhibited multi-drug resistance. Gram-positive and Gram-negative isolates were sensitive to amikacin [5], consistent with the findings of Essomba et al. in 2013 [6].

Management and treatment of postoperative SSIs remains a significant concern for surgeons and physicians in health care facilities [2]. AMR patterns of bacterial isolates keep changing and evolving with time, increasing resistance to first-line antibiotics [2,7]. This poses a major burden to the management of SSIs [7]. SSIs vary between developed and developing countries, according to type of operation and adopted surveillance protocol [8]. SSIs are one of the most common healthcare-associated infections in developed and LMICs [3,8]. SSI is a significant source of postoperative morbidity resulting in longer hospitalization, increased cost, and increased incidence of postoperative mortality, as most infections result from wound contamination by endogenous bacteria from the patient's skin, mucous membrane, or hollow viscus. With the indiscriminate use of antimicrobial agents, most bacteria have developed resistance to antibiotics. For effective control of wound infections and judicious administration of therapy, data regarding the causative organisms, their antibiotic sensitivity patterns, and their unique characteristics must be made available [7]. Hence, it is of utmost importance to keep track of these changes by continuous surveillance. Estimating the burden of AMR with evidence-based knowledge on AMR patterns is therefore very important to improve infection control policies. Moreover, there is an undocumented increase in resistance to the FLA for prophylaxis and treatment of SSI in the YCH.

Therefore, we aimed to contribute to the improvement of infection control policies in our low economic setting, create awareness on AMR, and reduce the number of emerging resistant strains by providing data on common germs implicated in SSI and their antimicrobial resistance patterns.

2. Materials and Methods

2.1. Study Design and Setting

This prospective cohort study was carried out at the Yaoundé Central Hospital (YCH) from February 2021 to May 2021. It is a tertiary level hospital, with a capacity of 650 beds and 627 health personnel (70 doctors, 408 nurses/assistants/laboratory technician, and 114 administrative staff members). The surgical department has eight wards (maternity A, maternity B, general surgery, visceral surgery, paediatric surgery, urology, traumatology A, and traumatology B) [2].

2.2. Study Population and Sampling

Participants were selected using a convenience sampling method. We included patients who underwent surgery in the general surgical, urology, and traumatology units of YCH. The patients were followed up by nurses and attending surgical residents who diagnosed SSIs. SSI was defined and classified following the Centres for Disease Control criteria.

2.2.1. Inclusion and Exclusion Criteria

Overall, 246 patients underwent surgery in three main surgical departments: general surgery, orthopaedics, and urology. We excluded patients who had gross contamination of surgery site at the time of surgery [9]. We included 225 postoperative patients diagnosed with SSI who provided informed consent.

2.3. Identification of Germs

Pus swab samples of the surgical site were collected from 16 patients with SSIs and immediately transferred to the bacteriology laboratory. These pus swab samples were then cultured on nutrient, chocolate, and eosin methylene blue agar for 24–48 h aerobically and 24 h anaerobically on chocolate agar using an artisanal carbon dioxide jar at 37˚C.

2.3.1. Gram Staining

Gram staining was used to differentiate bacteria based on the thickness of their peptidoglycan layer. Gram-positive bacteria have a thick peptidoglycan layer that retains the primary stain (crystal violet), appearing purple, while Gram-negative bacteria have a thin layer and an outer lipid membrane that is dissolved by a decolorizer, causing them to lose the primary stain and take up the pink counterstain instead.

2.3.2. Differential Media

Mini galleries were prepared following the Yaoundé university teaching hospital germ identification file for 2020. The Catalase Test was used to identify organisms that produce catalase.

1. The oxidase test was used to identify bacteria containing cytochrome c oxidase. A reducing reagent is added directly to bacterial growth on solid media. A dramatic colour change occurs within seconds if the reducing agent becomes oxidized, indicating that cytochrome c oxidase is present [10]. The indole test was performed using Sugar, Indole, and Motility (SIM) media, which test for motility and sulphur reduction. The Indole test identifies bacteria capable of producing indole using the enzyme tryptophanase. The hydrolysis of tryptophan in SIM media can be detected by the addition of Kovacs' reagent after a period of incubation. When a few drops of Kovacs' reagent are added to the tube, it forms a liquid layer over the solid medium. DMABA then reacts with any indole present and produces a quinoidal compound that turns the reagent layer red [10].

3. Kligler's Iron Agar (KIA) was used to differentiate Enterobacteriaceae and to distinguish them from other Gram-negative

bacilli such as Pseudomonas or Alcaligenes. KIA differentiates bacteria based on glucose fermentation, lactose fermentation, and sulfur reduction [10]. A KIA with a yellow slant and butt at 24 h indicates that the organism ferments glucose and lactose. Gas produced by carbohydrate fermentation will appear as fissures in the medium or will lift the agar off the bottom of the tube [10]. All Enterobacteriaceae perform a one-step reduction of nitrate to nitrite. The nitrate test differentiates them from Gram-negative rods that do not reduce nitrate or reduce it beyond nitrite to N2 or other compounds [10].

2.4. Antimicrobial Susceptibility Testing (AST)

2.4.1. Quality Control

We performed AST according to the Clinical and Laboratory Standards Institute in the USA and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) classification standard to classify the tested microorganisms [11]. We used these standards to classify the tested microorganism as clinically susceptible, intermediate, or resistant to the tested drug. For our quality control, we used the Comité de l'antibiogramme de la Société Française de Microbiologie 2020 and EUCAST standards.

2.4.2. McFarland Turbidity Standard

This standard was used as a reference to adjust the turbidity of bacterial suspensions to estimate the number of bacteria within a given range for standardize microbial testing [10].

2.4.3. Disc Diffusion Test

1. Inoculum Preparation

The growth method was performed by selecting three to five well-isolated colonies of the same morphology from an agar plate using a loop and transferring the growth into a tube containing 4 to 5 mL of suitable broth medium. The broth culture was incubated until the turbidity was achieved mostly for 2 to 6 hours at 35˚C.

Regarding the direct colony suspension method, the inoculum was prepared by making a direct broth or saline suspension of isolated colonies selected from a 24- to 48-h agar plate (chocolate agar).

2. Inoculation of Test Plates

Within 15 min after adjusting the turbidity of the suspension, a sterile cotton swab is dipped into the adjusted suspension and the swab is rotated many times and pressed against the wall of the tube firmly. This will remove the excess inoculum from the swab [10]. The swab is then streaked on the agar plate about two more times, rotating the plate by approximately 60° each time to ensure an even distribution of inoculum. Finally, the rim of the agar is swabbed. The agar plates contained the following antibiotic discs—Beta lactams (ceftriaxone [Cro, 30 µg], cefuroxime [Crx, 30 µg], and Augmentin [Aug, 30 µg]), aminoglycosides (gentamicin [GN, 30 µg], fluoroquinolones (levofloxacin (ofl, 5 µg) and ciprofloxacin, [Cpr]), macrolides (erythromycin [Ery, 10 µg] and azithromycin, [Azt, 5 µg]), carbapenem (imipenem, [Imp, 10 µg]), and amikacin (30 µg). The plates were left and incubated for colonies to grow at 35˚C for 16 to 18 h.

3. Reading Plates and Interpreting Results

After 16–18 h of incubation, each plate was examined. The diameter of the zones of complete inhibition was measured using the scale. The plates were inverted, and their diameters were measured using a ruler [11]. The zone margin was defined as the area showing no obvious, visible growth that could be detected with the unaided eye. Faint growth of tiny colonies observed or detected only with the help of a magnifying lens, limited to the edge of the zone of inhibited growth, was ignored. Many discrete colonies growing within a clear zone of inhibition were sub cultured, re-identified, and retested for further analysis [11].

2.5. Outcomes

The outcome variables comprised culture-positive SSIs (with antibiotic susceptibility) and SSI events. The predictive variables comprised comorbid conditions, hemoglobin level, glycemia, use of orthopedic devices, type of surgery, duration of surgery, antibiotic prophylaxis, wound class, smoking, and alcohol consumption.

2.6. Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board of the Faculty of Health Sciences, University of Buea. Administrative approvals were obtained from the Faculty of Health Sciences, University of Buea, and the YCH. Furthermore, authorizations were obtained from the head of the various surgical units and the nurses in charge. Following clear explanation of the study procedure, the participants provided written informed consent.

2.7. Data Collection and Analysis

Data was collected using a structured questionnaire following a one-on-one interview with the patient and review of the patient's surgical files. The participants' data on demographics, relevant history, type of surgery, duration of surgery, and preparation for surgery were obtained. After filling the questionnaire, pus swab samples were collected from the surgical site by the primary investigator who had a surgical face mask on and washed hands before and after sample collection for each participant.

2.8. Data Management and Analysis

The data was entered into EPIDATA version 3.1. The data was analyzed using Microsoft Excel 2016, EPI-INFO (Version 7.0), and Statistical Package for the Social Sciences (Version 23, IBM). Data was stored discretely on SkyDrive and other devices. Participants were assigned identification codes to ensure patient anonymity.

Categorical variables are presented as frequencies and proportions, while continuous variables are presented as means (standard deviations) or median (interquartile range). We compared ratios and proportions using Pearson's chi-square test and compared means using the Student's t-test. The values are expressed as an odds ratio (OR) with 95% confidence interval (CI) and cor-

responding p values. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Participant Sociodemographic Characteristics

Of the 246 patients who underwent surgery in the three main surgical wards (surgery, 136 [60.4%]; orthopedics, 86 [38.2%]; and urology, 34 [15.1%]), 225 were included into the study (Figure 1). Of these, 114 (38.9 ± 18.1, 50.7%) were 21–40 years old and 64.9% had attended secondary institutions. Hair removal was performed for 132 (58.7%) participants, and 121 (53.8%) received antibiotics 15 to 30 min before the onset of surgery. Most surgeries were general surgeries 126 (56%). Most participants received general anesthesia (131, [58.2%]), compared to spinal anesthesia (58 [25.8%]). Drains were used for 111 (49.3%) participants. The most common drugs prescribed postoperatively were cefuroxime (32.9%), ceftriaxone (30%), metronidazole (82.1%), and gentamicin (59.8%).

Table 1: Demographic characteristics.

Characteristics	Frequency	Percentage
Age (years) 0–20	72	32.0
21–40	114	50.7
41–60	35	15.6
< 60	4	1.8
Mean ± SD	38.9 ± 18.1	
Sex Male	120	53.3
Female	105	46.7
Level of education Primary	2	0.9
Secondary	146	64.9
Tertiary	77	34.2

SD, standard deviation.

3.2. Prevalence of SSI

The overall prevalence of SSI was 10.67%, with the traumatology ward having the highest prevalence of SSI (13.64%), followed by the general surgery ward (11.11%); the urology ward had the least (3.03%) (Figure 2). Seventeen (70.8 %) participants had superficial incisional SSIs, 6 (25 %) had deep incisional SSI and 1 had (4.2 %) organ/space SSI (Figure 2).

3.3. Bacteriological Study

3.3.1. Wound Culture

Of the 24 patients with SSI, 17 (70.8%) had a positive culture, while 7 (29.2%) had a negative culture (Figure 3). Twenty-seven bacterial isolates and 1140.716 (59.3%) were observed (Figure 4). Further, 127 Staphylococcus aureus and 27 (8.5%) Klebsiella spp. were isolated (Figure 5).

Table 2: Bivariate analysis of sociodemographic characteristics and SSI.

Characteristics	n (%)	Surgical Infection positive	COR (95%CI)	p value
Age (years)				
0–20	72 (32.0)	1 (4.2)	1.3 (0.09–3.03)	0.41
21–40	114 (50.7)	15 (62.5)	0.12 (0.05–3.8)	0.35
41–60	35 (15.6)	4 (16.7)	1.34 (0.81–6.90	0.67
< 60	4 (1.8)	4 (16.7)	1	
Sex				
Male	120 (53.3)	13 (54.2)	1.04 (0.44–2.43)	0.93
Female	105 (46.7)	11 (45.8)	1	
Level of education				
Secondary	148 (65.8)	17 (70.8)	1.30 (0.51–3.28)	0.58
Tertiary	77 (34.2)	7 (29.2)	1	

COR, crude Odds ratio; CI, confidence interval.

3.4. Risk Factors for SSI

3.5. Perioperative Care and SSI

Antibiotics were administered 7 days before surgery.

Table 3: Bivariate analysis of perioperative care and SSI.

Characteristics	n (%)	Surgical infection positive Cases n (%)	COR (95% CI)	p value
Timing of surgery				
Emergency	(60.9)	(50.0)	0.61 (0.26–1.42)	0.25
Elective general	(39.1)	(50.0)	1	
Yes	(56.0)	(62.5)	1.35 (0.56–3.23)	0.49
No **Urology**	(44.0)	(37.5)	1	
Yes	(14.7)	(4.2)	0.23 (0.03–1.76)	0.16
No **Wound Class**	(85.3)	(95.8)	1	
Clean	(16.4)	(25.0)	0.6 (0.19–1.91)	0.39
Clean contaminated	(29.8)	(8.3)	0.1 (0.02–0.47)	0.004
Contaminated	(37.3)	(29.2)	0.28 (0.09–0.83)	0.02
Dirty **Anesthesia**	(16.4)	37.5)	1	
General	(58.2)	(70.8)	1.29 (0.48–3.46)	0.61
Regional	(16.0)	(4.2)	0.25 (0.03–1.15)	0.3
Spinal	(25.8)	(25.0)	1	
Surgeon				
Surgeon	(64.0)	(87.5)	0.22 (0.06–0.8)	0.02
residents	(36.0)	(12.5)	1	
Drain				
Yes	(49.3)	(79.2)	4.5 (1.62–12.53)	0.004
No **Implants**	(50.7)	(20.8)	1	
Yes	(17.8)	(25.0)	1.63 (0.61–4.43)	0.33
No **Duration of surgery (hours)**	(82.2)	(75.0)	1	
< 2	(69.8)	(29.2)	0.14 (0.05–0.36)	0.00
2–4 **Hair removal**	(30.2)	(70.8)	1	
Yes	(58.7)	(70.8)	1.81 (0.72-4.57)	0.2
No **Use of antiseptic solution**	(41.3)	(29.2)	1	
Yes	(99.6)	(100)	-	-
No	(0.4)	(0.0)	-	
Prophylaxis administered				
Yes	224 (99.6)	23 (95.8)	-	-
No	1 (0.4)	1 (4.2)	-	-
Duration of antibiotic use (minutes)				
< 15	98 (43.6)	5 (21.7)	0.013 (0.001–0.14)	0.000
15–30	121 (53.8)	14 (60.9)	0.033 (0.003–0.314)	**0.003**
> 30	5 (2.2)	4 (17.4)	1	

COR, crude Odds ratio; CI, confidence interval.

3.6. Infection

Diabetes mellitus, alcohol consumption, and duration of antibiotic use before surgery, were significantly associated with SSIs. Surgeons 4.3 (1.04–8.45)

Table 4: Infection.

Characteristics	AOR (95%CI)	P-value
Cardiovascular diseases		
Yes	3.65 (0.22–12.3)	0.36
No **Diabetes mellitus**	1	
Yes	2.23 (0.14–15.3)	0.57
no **Hair removal**	1	
Yes	0.56 (0.12–2.52)	0.45
No **Duration of antibiotics administered (minutes)**	1	
< 15	08 (0.005–1.46)	0.04
15–30	0.19 (0.01–3.14)	0.25
> 30 **Wound Class**	1	
Clean	0.04 (0.004–0.44)	0.008
Clean contaminated	0.061 (0.006–0.6)	0.01
Contaminated	0.05 (0.008–0.35)	0.002
Dirty **Surgeon**	1	
Residents	1	0.01
Surgeons	4.3 (1.04–8.45)	

3.7. Antibiotic Susceptibility Testing

Ceftriaxone had the most resistance (88.2%), with a sensitivity of 5.9%, followed by cefuroxime with a resistance of 70.6% and sensitivity of 17.6%. Gentamicin had a resistance of 52.9% and a sensitivity of 29.4%. Erythromycin had a sensitivity of 64.7% and a resistance of 23.5%. Amoxicillin-clavulanic acid had a sensitivity of 41.2% and a resistance of 29.4%. Vancomycin had a sensitivity of 47.1% and a resistance of 23.5%. Azithromycin had a sensitivity of 52.9% and a resistance of 29.4%. Ciprofloxacin had a sensitivity of 41.2% and a resistance of 29.4%. Levofloxacin had a sensitivity of 52.9% and a resistance of 29.4%. Imipenem was the second most sensitive (82.4%) antibiotic, with a resistance of 11.8%. Amikacin was 100% sensitive to all bacteria (Figure 6).

3.8. Antimicrobial Resistance Pattern

Proteus mirabilis, Streptococcus, and Escherichia coli strains showed the most multi-drug resistance. Klebsiella spp. isolates were 100% resistant to ceftriaxone, 80% resistant to cefuroxime, and 20% resistant to amoxicillin-clavulanic acid. Streptococcus was resistant to all antibiotics at 100% except for amikacin, imipenem and amoxicillin-clavulanic acid. Pseudomonas aeruginosa was resistant only to ceftriaxone (50%), and coagulase-negative streptococci was sensitive to all antibiotics.

Table 5: Antimicrobial resistance pattern.

Antibiotic	Streptococcus	Escherichia coli	Staphylococcus aureus	Pseudomonas aeruginosa	Klesiella sp.	Enterobacter cloacae	Coagulase -negative Staphylococcus
Ceftriaxone	1 (100%)	5 (100%)	7 (87.5%)	1 (50%)	5 (100%)	2 (66.67%)	
Cefuroxime	1 (100%)	4 (80%)	4 (50%)	0	4 (80%)	2 (66.67%)	
Amoxicillin-clavulanic acid	0	3 (60%)	1 (12.5%)	0	1 (20%)	1 (33.33%)	

Imipenem	0	1 (20%)	0	0	1 (20%)	0	
Amikacin	0	0	0	0	0	0	
Gentamicin	1 (100%)	3 (60%)	3 (37.5%)	0	2 (40%)	2 (66.67%)	
Vancomycin	1 (100%)	2 (40%)	1 (12.5%)	0	0	1 (33.33%)	
Azithromycin	1 (100%)	2 (40%)	1 (12.5%)		1 (20%)	1 (33.33%)	
Ciprofloxacin	1 (100%)	2 (40%)	1 (12.5%)	0	1 (20%)	1 (33.33%)	
Erythromycin		2 (40%)	1 (12.5%)	0	0	1 (33.33%)	
Levofloxacin	1 (100%)	2 (40%)	1 (12.5%)		1 (20%)	1 (33.33%)	

3.9. Multi-Drug Resistance

Most of the organisms that were isolated demonstrated multi-drug resistance as shown in Table 6.

Table 6: Multi-drug resistance.

Organism	**S 1.1.1**	**(%) R_1, n 1.1.2**	**(%) R_m, n 1.1.3**
Streptococcus	0 1.1.4	0 1.1.5	(100%) 1 1.1.6
Escherichia coli	0 1.1.7	(40%) 2 1.1.8	(60%) 3 1.1.9
Staphylococcus aureus	(12.5%) 1 1.1.10	(50%) 4 1.1.11	(37.5%) 3 1.1.12
Pseudomonas aeruginosa	(50%) 1 1.1.13	(50%) 1 1.1.14	0 1.1.15
Klebsiella spp	0 1.1.16	(60%) 3 1.1.17	(40%) 2 1.1.18
Enterobacter cloacae	(33.33%) 1 1.1.19	0 1.1.20	(66.67%) 2 1.1.21
Coagulase-negative staphylococcus	(100%) 1 1.1.22	0 1.1.23	0 1.1.24
Proteus mirabilis	0 1.1.25	(50%) 1 1.1.26	(50%) 1 1.1.27

Note: **n,** Number of bacterial isolates; **S**, Sensitive to all antibiotics tested; **R1**, Resistance to one class of antibiotics; **Rm**, Resistance to 2 or more classes of antibiotics (multi-drug resistance).

4. Discussion

Our objectives were to evaluate the prevalence of SSIs in the YCH, establish antimicrobial patterns in patients with SSI after surgery at the YCH, determine which germs are frequently encountered in SSIs, assess the risk factors for SSI, and describe their correlation with identified AMR patterns. The knowledge of antibiotic resistance by bacteria recovered from SSIs is critical for the optimization of the prophylactic antibiotics used for surgical maneuvers [12]. In our study, the overall prevalence of SSI in the traumatology, urology, and general surgical wards of the YCH was 10.67%, which was relatively higher than that reported by Essomba et al. in Cameroon (9.4%) [13] and Mukagendaneza et al. in Rwanda (10.9%) [14]. The prevalence gotten from our study was relatively lower than that gotten by Mezemir et al. from Ethiopia in 2020 [15] and Ngowe et al. [16], from Limbe in 2014 [16]. This could be explained by the fact that in their study, all surgical patients shared one pavilion ward, regardless of the surgical subspecialty.

Among all the SSI cases, 17 (70.8 %) had superficial incisional SSIs, 6 (25 %) had deep incisional SSIs, and 1 (4.2 %) had organ/space SSIs. These results are similar to those of Essomba et al. [38]. In our study, 16.7% (4 of 24) of patients with SSIs had diabetes, consistent with the study by Aga et al. conducted in 2015 in Israel [17]. In addition, in 2020, Raouf et al. reported that of 34 of 580 patients with diabetes had SSIs [8]. In our study, patients with diabetes were five times more likely to develop SSIs than patients without. Diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose, which leads to serious damage to the heart, blood vessels, eyes, kidneys, and nerves. It weakens the immune system when poorly managed, making the body more susceptible to infections and SSIs. The overall culture positivity was 70.8%, similar to that in Ethiopia (70.5%) [43] and Uganda [19]. However, this was relatively lower than that found by Metwally and Aamir in Egypt in 2020 [20]. Our study revealed that S. aureus was the leading isolated pathogen (29.6%). S aureus is the most common isolate from wound infections in many countries, including Egypt [20,21], Brazil [22], Craiova [12], Nepal [23] and Ethiopia [18]. However, we noticed that most isolated organisms were Gram-negative bacilli with a predominance of E. coli and Klebsiella spp. (18.5% each) followed by Enterobacter cloacae, Proteus mirablis, and Pseudomonas aeruginosa. The antibiotic susceptibility results revealed that a high percentage of resistance was seen for most of the bacterial isolates. Ceftriaxone (88.2%), cefuroxime (70.6%), and gentamicin (52.9%) had the highest resistance rates, consistent with findings in India [24], Nigeria [25], and Uganda [2,26]. This could be explained by the routine prescription of cephalosporins and aminoglycosides in these centers. Amikacin (100%) and imipenem (82.5%) were the most sensitive antibiotics and drugs of choice against all the bacteria strains isolated, consistent with findings in Nigeria [25] and Uganda [2,26].

Most of the bacteria isolated in this study demonstrated multi-drug resistance, especially the strains of Streptococcus, Proteus

mirabilis, and Escherichia coli. This suggests a very high resistance gene pool, perhaps due to gross misuse, overuse, or inappropriate use of antibiotics. The pattern is best understood in terms of selective pressure exerted on the organisms based on the current use of antibiotics [2,49].

4.1. Strengths and Limitations

This study had some limitations. First, the limited access to all surgical wards especially the neurological and obstetrics/gynecology wards limited the generalizability of the findings. Second, proper follow-up of patients could not be accomplished; most of the patients did not return for wound dressing after their discharge. Nonetheless, the prospective nature of this study enhances reliability of the data and allows for real-time data collection, which minimizes recall bias. Second, the study included patients with clean, clean contaminated, contaminated, and dirty wounds. This variety allows for a more comprehensive analysis of SSIs across different wound classifications, facilitating the identification of specific risk factors and microbial patterns associated with each type.

5. Conclusion

The prevalence of SSI was high in this study, with the highest prevalence from the traumatology wards. Staphylococcus aureus was the most common isolated germ, with the least being coagulase-negative Staphylococcus and Streptococcus. Multidrug resistance was seen among all bacterial isolates especially to ceftriaxone, cefuroxime and gentamycin. Amikacin was the most sensitive antibiotic. The findings of our study suggest that routine antibacterial susceptibility testing should be conducted for all patients before and after surgery. We recommend further research on this topic using prospective study designs and a larger sample size.

References

1. Dunachie SJ, Day NP, Dolecek C. The challenges of estimating the human global burden of disease of antimicrobial resistant bacteria. Curr Opin Microbiol. 2020; 57: 95-101.
2. Raza MS, Chander A, Ranabhat A. Antimicrobial susceptibility patterns of the bacterial isolates in post-operative wound infections in a tertiary care hospital, Kathmandu, Nepal. Open J Med Microbiol. 2013; 03(03): 159-63.
3. Sartelli MC, Hardcastle T, Catena F, Chichom-Mefire A, Coccolini F. Antibiotic use in low and middle-income countries and the challenges of antimicrobial resistance in surgery. Antibiotics. 2020; 9(8): 497.
4. Palle JN, Bassah N, Kamga HLF, Nkwelang G, Akoachere JF. Current antibiotic susceptibility profile of the bacteria associated with Surgical wound infections in the Buea health district in Cameroon. Afr J Clin Exp Microbiol. 2014; 15(1): 27-34.
5. https://www.nepjol.info/index.php/JNHRC/article/view/18185.
6. Essomba N, C, J A, R E, A E, Banock L. Isolation of bacteria in surgical siteinfections and determination of their sensitivity to commonly prescribed antibiotics. 2021.
7. Kurhade A, Akulwar S, Mishra M, Kurhade G, Justiz-Vaillant A. Bacteriological study of post-operative wound infections in a tertiary care hospital. J Bacteriol Parasitol. 2015; 30: 251.
8. Raouf M, Ghazal T, Kassem M, Agamya A, Amer A. Surveillance of surgical-siteinfections and antimicrobial resistance patterns in a tertiary hospital in Alexandria, Egypt. J Infect Dev Ctries. 2020;14(03): 277-83.
9. Lubega A, Joel B, Justina Lucy N. Incidence and etiology of surgical site infections among emergency postoperative patients in Mbarara regional referral hospital, south western Uganda. Surg Res Pract. 2017; 2017: 1-6.
10. A Photographic Atlas for the Microbiology Laboratory 4th Edition [Internet]. Medical Books On-Line Library. 2018.
11. Antimicrobial Susceptibility Testing by CLSI method. Biomall Blog. 2018.
12. Călina D, Docea AO, Rosu L, Zlatian O, Rosu AF, Anghelina F. Antimicrobial resistance development following surgical site infections. Mol Med Rep. 2017; 15(2): 681-8.
13. Essomba N, Avomo J, Esiene A, Banock L, Abologo AL. P Prevalence of surgical site infections and evaluation of risk factors after surgery, case of three public hospitals in Cameroon. JMMS. 2013; 4(6): 241-6.
14. Mukagendaneza MJ, Munyaneza E, Muhawenayo E, Nyirasebura D, Abahuje E. Incidence, root causes, and outcomes of surgical site infections in a tertiarycare hospital in Rwanda: a prospective observational cohort study. Patient Saf Surg. 2019;13(1):10.
15. Mezemir R, Seid A, Gishu T, Demas T, Gize A. Prevalence and root causes of surgicalsite infections at an academic trauma and burn center in Ethiopia: a cross-sectional study. Patient Saf Surg. 2020; 14(1): 1-7.
16. Marcelin NN. Prevalence and risk factors associated with post operative infections in the Limbe regional hospital of Cameroon. Open Surg J. 2014; 8(1): 1-8.
17. Aga E, Keinan-Boker L, Eithan A, Mais T, Rabinovich A, Nassar F. Surgical site infections after abdominal surgery: incidence and risk factors. a prospective cohort study. Infect Dis. 2015; 47(11): 761-7.
18. Dessalegn L, Shimelis T, Asfaw E, Gebre-Selassie S. Aerobic bacterial isolates frompost-surgical wound and their antimicrobial susceptibility pattern: a hospital based cross-sectional study. J Med Res. 2014; 3: 18-23.
19. Hope D, Ampaire L, Oyet C, Muwanguzi E, Twizerimana H, Apecu RO. Antimicrobial resistance in pathogenic aerobic bacteria causing surgical site infections in Mbarara regional referral hospital, Southwestern Uganda. Sci Rep. 2019; 9(1): 17299.
20. Metwally W, Aamir R. Prevalence and antimicrobial resistance patterns of nosocomialpathogens causing Surgical Site Infections in an Egyptian University hospital. Microbes Infect Dis. 2020; 1(3): 226-37.
21. 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. 2009; 18(2): 12.

22. Carvalho RLR de, Campos CC, Franco LM de C, Rocha ADM, Ercole FF. Incidence and risk factors for surgical site infection in general surgeries. Rev Lat Am Enfermagem. 2017; 25: e2848.

23. Chaudhary R, Thapa SK, Rana JC, Shah PK. Surgical site infections and antimicrobial resistance pattern. J Nepal Health Res Counc. 2017; 15(2): 120-3.

24. Bacteriological Profile of Surgical Site Infections and Their Antibiogram: A Study FromResource Constrained Rural Setting of Uttarakhand State, India 2021.

25. Ehiaghe JI, Nwiyi PO. Prevalence of plasmid and antimicrobial resistance inpseudomonas aeruginosa isolated from surgical wound infections in Nigeria. J Sci Sustain Technol JSST. 2018; 1(2): 199-210.

26. Seni J, Najjuka CF, Kateete DP, Makobore P, Joloba ML. Antimicrobial resistance in hospitalized surgical patients: a silently emerging public health concern in Uganda. BMC Res Notes. 2013; 6(1): 298.