Surgical Antimicrobial Prophylaxis and Incidence of Surgical Site Infections at Ethiopian Tertiary-Care Teaching Hospital

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ABSTRACT

BACKGROUND: Surgical site infections (SSIs) are infections that develop within 30 days after an operation or surveillance of surgical wound infection implementation within 90 days after surgery when an implant is placed. The objective of this study was to assess preoperative and postoperative antimicrobial use in St. Paul's Hospital Millennium Medical College (SPHMMC), Addis Ababa, Ethiopia.

METHODS: A hospital-based cross-sectional study was undertaken in surgery wards of SPHMMC for 4 months by reviewing 413 patients' charts. All patients 13 years and older who were admitted and underwent different types of surgical procedures were included in the study. Epi info 7 was used for data entry, and then data were exported to Statistical Package for Social Sciences (SPSS) version 20.0 software for analysis. Descriptive analyses were computed and rate of SSI was calculated in this study. Moreover, bivariate analysis was done to examine the relationship between the outcome variable and predictor variables with a value of $P < .2$ retained for subsequent multivariate analyses using multiple logistic regressions. P value of <.05 was considered as statistically significant.

RESULTS: Out of 413 patients, 152 (36.8%) were operated for general surgery, and the remaining were for other types of surgeries. Most of the patients, 196 (79.7%), were managed by a single surgical antibiotic agent, followed by 2 agents (20.3%) for surgical prophylaxis indication. Surgical site infections occurred in 46 (11.1%) patients before discharge from the hospital. In those patients who need treatment for SSIs, almost half of them (49.5%) received combination therapy of ceftriaxone and metronidazole. Emergency surgical cases were 2.647 times more likely to develop SSIs than the elective surgical cases (adjusted odds ratio [AOR] = 2.647; 95% confidence interval [CI] = 1.406-4.983; $P = .003$). Patients who did not receive antibiotic prophylaxis were 2.572 times more likely to develop SSIs compared to those who received antibiotic prophylaxis (AOR = 2.572; 95% CI = 1.02-6.485; $P = .045$). Clean-contaminated and contaminated types of wound were a protective factor against SSI in our study.

CONCLUSIONS: This study indicated that most of the patients (72.1%) received surgical antimicrobial prophylaxis. The overall incidence rate of SSIs was 11.1% in the studied hospital. Ceftriaxone was the most commonly used drug. Being not receiving prophylaxis, wound class, and surgery types were significantly associated with the development of SSI.

KEYWORDS: Surgical antimicrobial prophylaxis, surgical site infection, St. Paul's Hospital Millennium Medical College, Ethiopia

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Introduction

Centers for Disease Control and Prevention defines surgical site infections (SSIs) as infections that develop within 30 days after an operation or surveillance of surgical wound infection implemented within 90 days after surgery when an implant is placed. It is categorized into 3 levels (superficial incisional, deep incisional, and organ or space infection).[1] It is the most frequent type of health care-associated infection (HAI) in low- and middle-income countries (LMICs). Approximately 1 in 10 people who have surgery in LMICs acquires SSI.[2] Postoperative infections are the most common HAI in surgical patients.[3-7] Surgical site infections are the second most common hospital-associated infections accounting 14% to 16% of all hospitalized patients and 38% among that of surgical patients.[8-10] In developing countries, especially in sub-Saharan Africa, the figure is twice or 3 times higher than in developed countries.[11] Surgical site infection is also reported as the second most common HAI in Europe and the United States. In Europe, SSI affects more than 500 000 people per year, costing €19 million; in the United States, SSI contributes to patients spending more than 400 000 extra days in the hospital, costing US$10 billion a year.[12,13]

Despite the advances in surgical techniques and pathogenesis understanding of surgical wound infections, SSIs continue to be a major challenge for surgical society.[14,15] Hence, antimicrobial prophylaxis should be started prior to contamination, which is considered essential to control bacterial growth and significantly lower the incidence of SSIs.[10,16,17] It is estimated that 60% of SSIs are preventable, mostly related to the use of recommended evidence-based practices such as the timing, selection, and duration of preoperative prophylactic antibiotics.[18,19]

Antibiotics in surgical wards are indicated for prevention of postoperative infection or for the treatment of established infections.[20,21] Almost 30% to 50% of antimicrobials used in hospitals are prescribed for surgical prophylaxis and of which 30% to 90% is inappropriate.[22,23] Furthermore, they are frequently used in wrong timing, for long period, and with too broad-spectrum coverage.[24,25] Cephalosporin antibiotics (such as cefazolin) are first-line agents for most surgical procedures, targeting the most likely organisms while avoiding broad-spectrum antimicrobial prophylaxis that may lead to the development of antimicrobial resistance. The duration of surgical antimicrobial prophylaxis (SAP) should not exceed 24 hours.[26,27]

Appropriate antibiotic selection, the timing of the initial administration, the number of dosages administered during surgery, and postoperative medication use determine the effectiveness of the prophylaxis. Incorrect execution of any of these factors can influence the rate at which infections at the surgical site occur.[28,29]

Due to information gap about SAP regimen appropriateness in surgery wards of St. Paul's Hospital Millennium Medical College (SPHMMC), this study is aimed at assessing pattern of SAP and rate of SSIs in surgically operated patients.

Materials and Methods

Study setting

This study was employed in surgery wards of SPHMMC. It is one of the largest tertiary referral government hospitals, which is located in Addis Ababa, Ethiopia, with bed capacity of 654. The hospital gives diagnostic and treatment service for about 400 000 patients per year. It provides surgery service for around 12 650 patients per year.

Study design and period

A hospital-based cross-sectional study was conducted by simple random sampling method (every patient in the study population has an even chance and likelihood of being selected in the study) to collect data by reviewing the patients' charts for 4 months (from June 10 to September 10, 2016) in patients admitted to surgical wards of SPHMMC. All patients were admitted for surgery at surgical wards, and who operated for general, orthopedic, gynecology and obstetrics, urology, and neurology surgical procedures during the study period were source and study population, respectively, in our study. Study participants under the age of 13 years, who operated in another hospital and later referred to SPHMMC, were excluded from our study.

Sample size and sampling technique

The sample size was determined using the single population proportion formula[30] with a P value of .5 and a marginal error of 5% and CI of 95% ($Z = 1.96$). Hence, the sample size was calculated to be 384 participants. Considering 10% of incomplete patient records, the sample size becomes 422. Finally, the required proportion of the sample was taken from each surgical ward. Finally, we included 413 study participants for analysis as 9 patients did not fulfill the inclusion criteria.

Data collection, management, and quality assurance

Data were collected using a structured data collection tool, which contains the age, sex, types of surgery, development of SSIs, class of SSI, surgical ward in which the patient was admitted, prophylactic and postoperative treatment antimicrobial agent prescribed, route and time of antimicrobial administration, intraoperative re-dosing, and base of antimicrobial prescription for postoperative treatment; 4 clinical pharmacists were recruited and trained on the data collection procedure using data abstraction tool for 1 day. The data collection tool was pretested on 5% of the study participants outside of the study period, and the necessary amendment was made to the final data collection tool. The collected data were checked for completeness and the same procedure was followed for data collection.

Statistical analysis

The collected data were checked and cleaned for any deficit before data entry. Epi-info 7 was used for data entry, and then, data were exported to SPSS version 20.0 for analysis. Descriptive analyses were computed and rate of SSI was calculated in this study. Bivariate analyses were done to examine the relationship between the outcome variable and predictors; variables with the value of $P < .2$ were retained for subsequent multivariate analyses using multiple logistic regressions. The P value of $< .05$ was considered as statistically significant.

Operational definitions

Surgical site infections are infections that develop within 30 days after an operation or surveillance of surgical wound infection implementation within 90 days after surgery when an implant is placed.

Surgical antimicrobial prophylaxis refers to the use of antibiotics for the prevention of SSIs and does not include preoperative decolonization or treatment of established infections.

Ethical considerations

Ethical approval was obtained from the Ethical Review Board of School of Pharmacy, College of Health Sciences, Addis Ababa University, and SPHMMC Research Review Board before data collection. Privacy and confidentiality were guaranteed by excluding patient identifiers and coding it. Only the researcher or data collectors had access to the data.

Results

Sociodemographic and clinical characteristics

We included 413 patients in this study. Among all types of surgical procedures conducted, 231 (55.9%) were for male patients. Study participants' age ranges from 13 to 82 years with a mean of 38.1 (SD = 15.1) years and a median of 36.4 (range = 20.2-57.1) years. A total of 152 (36.8%) patients were admitted for general surgery and the remaining were for other types of surgeries (Table 1).

Antibiotics utilization practice in surgery

Most of the study participants (82.6%) received antibiotics for prophylaxis (72.1%) and treatment (27.9%) indications. In this study, most of the patients, 179 (79.7%), were managed by a single antibiotic for prophylaxis indication and followed by 2 antibiotics (50; 20.3%) for the same purpose. Study participants who received treatment antibiotics, almost half of them (49.5%), were prescribed with ceftriaxone and metronidazole in injection form. The most preferred route of administration was parenteral (IV) route: 220 (89.4%) and 69 (72.7%), for prophylaxis and treatment indications, respectively (Table 2).

Regarding the timing of providing preoperative prophylaxis, half of the patients received antibiotics 30 minutes before surgery and the same number of study participants received the postoperative prophylaxis for ⩾48 hours (Table 3), which was the inappropriate duration. Surgical antimicrobial prophylaxis dosages were appropriate in 91.1% of the study participants.

Incidence of SSIs

Out of 413 patients who operated for different surgery indications, SSIs occurred in 46 (11.1%) patients before discharge from hospital.

Factors associated with SSIs

There were 7 variables in binary logistic regression (age, sex, comorbid illness, the status of antimicrobial prophylaxis use, types of surgery, duration of surgery, and class of wound) which had a *P* value of ⩽.2 and became candidates for multiple logistic regression. Emergency surgical cases were 2.6 times more likely to develop SSIs than the elective surgical cases (AOR = 2.647; 95% CI = 1.4060-4.983). Patients who were without antibiotic prophylaxis (among those who SAP were recommended but not received) were 2.6 times more likely to develop SSI compared to those who had received preoperative antibiotic prophylaxis (AOR = 2.572; 95% CI = 1.02-6.485; Table 4).

In this study, not receiving SAP, patients underwent emergency surgeries, and those with clean-contaminated and contaminated types of wound were significantly associated with the occurrence of SSIs.

Table 1. Sociodemographic and clinical characteristics of study participants (N = 413).

VARIABLE DESCRIPTION	N	%
Sex		
Male	231	(55.9)
Female	182	(44.1)
Age in years		
<20	13	(3.1)
20-39	241	(58.4)
40-59	106	(25.7)
⩾60	53	(12.8)
Presence of comorbid illness		
Yes	110	(26.6)
No	303	(73.4)
Types of surgery		
Elective	281	(68)
Emergency	132	(32)
Types of surgical procedures conducted		
General surgery	152	(36.8)
Urological surgery	76	(18.4)
Gynecology and obstetrics surgery	64	(15.5)
Orthopedics surgery	92	(22.3)
Neurosurgery	29	(7)
Wound class		
Clean	95	(23)
Clean-contaminated	172	(41.6)
Contaminated	63	(15.3)
Dirty	83	(20.1)
Patient's antibiotic status		
Yes	341	(82.6)
No	72	(17.4)
SSI development		
Yes	46	(11.1)
No	367	(88.9)
Duration of surgery (in hours)		
<1	175	(42.4)
1-2	154	(37.3)
>2-3	52	(12.6)
>3-4	25	(6.0)
>4	7	(1.7)

Abbreviations: SSI, surgical site infection.

Table 2. Practice of surgical antimicrobial prophylaxis and treatment (N = 341).

PRACTICE OF PRESCRIBING ANTIMICROBIALS	FOR PROPHYLAXIS, N (%) (246, 100)	FOR TREATMENT, N (%) (95, 100)
Antibiotics prescribed		
Ceftriaxone	174 (70.7)	13 (13.7)
Ceftriaxone + metronidazole	22 (9.0)	47 (49.5)
Ceftriaxone + ampicillin	24 (9.8)	0 (0)
Ceftriaxone + vancomycin	0 (0)	14 (14.7)
Ceftriaxone + gentamycin	4 (1.6)	5 (5.3)
Cloxacillin	2 (0.8)	6 (6.3)
Ciprofloxacillin	16 (6.5)	10 (10.5)
Amoxicillin	4 (1.6)	0 (0)
Route of administration		
Intravenously (IV)	220 (89.4)	69 (72.7)
Per oral (PO)	8 (3.3)	16 (16.8)
IV and PO	18 (7.3)	10 (10.5)

Table 3. Timing, duration, and appropriateness of surgical antimicrobial prophylaxis (N = 246).

PRACTICE OF SURGICAL ANTIMICROBIAL PROPHYLAXIS	NUMBER (%)
Timing of SAP	
30 minutes before surgery	124 (50.4)
At the time of anesthesia	64 (26)
30 minutes to 1 hour before incision	34 (13.8)
1 to 2 hours before incision	2 (0.8)
Not known	22 (9)
Duration of SAP administration	
Single dose	28 (11.4)
24 hours	93 (37.8)
48 hours	47 (19.1)
72 hours	56 (22.8)
>72 hours	22 (8.9)
Indication of SAP	
Indicated and administered	224 (91.1)
Not indicated but administered	22 (8.9)
Choice of antibiotics	
Appropriate	205 (91.5)
Inappropriate	19 (8.5)
Dosage appropriateness	
Accurate	224 (91.1)
Inaccurate	22 (8.9)
Duration of prophylaxis	
Correct	121 (49.2)
Incorrect	125 (50.8)
Route of administration	
Appropriate	224 (91.1)
Inappropriate	22 (8.9)

Abbreviations: SAP, surgical antimicrobial prophylaxis.

Discussion

In this study, preoperative and postoperative antibiotics were used, and incidence of SSIs was assessed in a tertiary-care teaching hospital in Addis Ababa, Ethiopia. Sociodemographic and clinical characteristics, antibiotics utilization practice in surgery, the practice of SAP and treatment, and factors associated with SSIs were studied.

During the study period, 524 patients were operated and 413 of them were included in the study. Out of 341 (82.6%) patients, antibiotics were prescribed for the purpose of SAP and/or treatment. SSIs were observed in 46 (11.1%) patients. The incidence rate of SSI was higher than the studies done in Qatar (5%),[17] India (3.38%),[1] and Brazil (3.4%).[31] This could be due to the involvement of most of the surgery types in our study and the total sample size difference. However, the higher incidence rate was reported from 2 Ethiopian studies (20.6%[32] and 19.1%)[3] and Uganda study (16.4%).[33]

The basis of antibiotics prescription both for prophylaxis (246; 72.1%) and treatment (95; 27.9%) was empirical in all patients. This result was similar to a study done in Namibia.[34] The most commonly used antibiotic was ceftriaxone for both indications, and it was the most commonly prescribed antibiotic in combination with other antibiotics in this study. This might be due to unavailability of the appropriate SAP agent like cefazolin.[35,36] This study result was in line with US study.[37]

Out of 246 patients who were given prophylactic antibiotics, 124 (50.4%) received prophylactic antibiotics 30 minutes before surgery. This result is supported with a study done on the feasibility of short-term prophylactic antibiotics in gastric cancer surgery.[38] According to American Family Physicians[39] recommendations, prophylactic antibiotics should be initiated within 1 hour before surgical incision and which supports our study finding as most of our study participants (224; 90.2%) received SAP within 1 hour before surgical incision. However, regarding the duration of pre and post prophylaxis, 28 (11.4%) patients received SAP as only pre-operative single dose and 125 (50.8%) received for extended duration (>24 to

Table 4. Factors associated with surgical site infections occurrence among surgical patients.

VARIABLES	SSI (N, %)	NO SSI (N, %)	AOR (95% CI)	*P* VALUE
Age in years				
⩽20	1 (7.7)	12 (92.3)	1	
20-39	21 (8.7)	220 (91.3)	0.360 (0.086-0.787)	.067
40-59	15 (14.2)	91 (85.8)	1.234 (0.389-3.306)	.918
⩾60	8 (15.1)	45 (84.9)	0.881 (0.249-2.451)	.771
Sex				
Male	33 (14.3)	198 (85.7)	0.596 (0.252-0.979)	.053
Female	13 (7.1)	169 (92.9)	1	
Presence of comorbid illness				
Yes	7 (6.4)	103 (93.6)	0.489 (0.211-1.131)	.094
No	39 (12.9)	264 (87.1)	1	
Prophylactic antibiotics				
Received	40 (16.3)	206 (83.7)	1	
Not received	6 (3.6)	161 (96.4	2.572 (1.020-6.485)	.045
Duration of surgery				
<1	18 (10.3)	157 (89.7)	1	
1-2	18 (11.7)	136 (88.3)	1.221 (0.606-2.462)	.577
>2-3	5 (9.6)	47 (90.4)	0.989 (0.346-2.823)	.983
>3-4	5 (20)	20 (80)	1.859 (0.569-6.076	.305
>4	0 (0)	7 (100)		.999
Types of surgery				
Elective	25 (8.9)	256 (91.1)	1	
Emergency	21 (15.9)	111 (84.1)	2.647 (1.406-4.983)	.003
Wound class				
Clean	5 (5.3)	90 (94.7)	1	
Clean contaminated	13 (7.6)	159 (92.4)	0.118 (0.033-0.416)	.001
Contaminated	10 (15.9)	53 (84.1)	0.293 (0.136-0.633)	.002
Dirty	18 (21.7)	65 (78.3)	0.694 (0.295-1.632)	.403

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; SSI, surgical site infection.

72 hours). According to the American Society of Health-System Pharmacists Therapeutic Guidelines,[40] the duration of antimicrobial prophylaxis should be less than 24 hours for most procedures. The reason for the extended use of SAP in this hospital might be associated with fear of high-level nosocomial infections in the country. In all study participants who received SAP, 224 (91.1%), accurate dose and appropriateness of administration routes followed in the study setting. The appropriateness related to dose and administration route might be associated with the implementation of clinical pharmacy service in the hospital.

Emergency surgical cases were 2.647 times more likely to develop SSIs than the elective surgeries ([AOR = 2.647; 95% CI: 1.406-4.983; *P* = .003]). The same association was reported by Watanabe et al[41] in their retrospective study. Patients who did not receive SAP were 2.572 times more likely to develop

SSI compared to those who received SAP ([AOR = 2.572; 95% CI: 1.02-6.485; P = .045]). This strengthens the importance of providing SAP to prevent SSIs.

This study has some strengths. Even if it is from a single hospital, we tried to include large number of participants with a period of 4 months. In addition, detailed information on clinical characteristics and parameters related to SAP were included in this study. However, there were also limitations in our study. This study was conducted in adult general, orthopedic, urology, obstetrics and gynecology, and neurology surgery wards of the hospital, so that it is not generalizable to the other patient population. Apart from this, the data retrieval was based on the written information in medical records, which might be confounded by personnel negligence in the documentation and thus may not reflect the real practice in some occasions (the timing and duration of antibiotic prophylaxis). Furthermore, as this study was carried out in 2016, it may have minimal applicability to the present (antibiotic prophylaxis) practice.

Conclusion and Recommendations

This study indicated that most of the patients (72.1%) received SAP antibiotics. The overall incidence rate of SSIs was 11.1% in studied hospital. Ceftriaxone was the most commonly used drug. Not receiving SAP, wound class, and surgery types were significantly associated with the development of SSI. Clean-contaminated and contaminated types of wound were a protective factor against SSI in our study. We recommend that the hospital should have SAP evidence-based guidelines in surgery wards by considering resistance pattern and common microorganisms responsible for SSI in consideration. This study suggests the need to avail most of the recommended SAP antibiotics, specifically cefazolin. It might also be important to perform continued surveillance of SAP practice and continuous educational programs for all surgical wards. We also recommend hospital infection control system, and wound surveillance program has to be established to reduce the surgical wound infection rate to acceptable standard.

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Author Contributions

KA conceived the study idea, developed the study design, conducted the study, and analyzed data. TA and WS enriched it. AA and TA did critical revisions of the manuscript for its important intellectual content and it was approved by KA and WS. All authors read and approved the final manuscript.

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Data Availability

All data contributing to this manuscript are available by request to the corresponding author.

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