Research Article
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A Cohort study of surgical site infection in infection present at time of surgery at three tertiary hospitals in the copperbelt province, Zambia

Abstract

Introduction: Infection present at the time of surgery is defined as an infection that is noted at the time of initial surgery and documented at the same depth of surgical site infection. Infection present at the time of surgery is found in emergency operations and dirty and contaminated wounds. This study aimed to determine the SSI prevalence and antimicrobial resistance of patients with Infection present at the time of surgery presenting to the 3 tertiary hospitals in Zambia.

Methodology: This was a cohort study conducted at 3 tertiary hospitals in the Copperbelt Province of Zambia.

Results: A total of 516 participants with Infection present at the time of surgery were included. The gender of participants with Infection present at the time of surgery included 322 males and 194 females. In this study, 117 (24.6%) developed surgical site infection. Therefore, the prevalence of SSI in patients who are treated for Infection present at the time of surgery after 30-day follow-up was 24.6%.

Conclusion: The prevalence of surgical site infection in Infection present at the time of surgery during 30-day follow-up was found to be 24.6%, and the top 4 organisms responsible for SSI after Infection present at the time of surgery was treated included *S aureus*, *E coli*, *P aeruginosa*, and *E agglomerans*, for the 3 tertiary institutions.

Keywords: SSI, surgical site infection, infection present at time of surgery, PATOS

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Introduction

Infection present at the time of surgery (PATOS) is defined as an infection that is noted at the time of initial surgery and is the same as the postoperative complication of surgical site infection (SSI) noted during follow-up, and at same depth of as the initial infection in the index of surgical procedure.[1] PATOS therefore occurs as SSI following an initial operation in which infection was noted and documented at the same depth of SSI.[2] To our knowledge, there is little published documentation of PATOS in Africa, including at developed centres. PATOS is found in wound-class categories that include emergency operations and dirty and contaminated wounds.[3] It follows that dirty and contaminated wounds may be difficult to distinguish from PATOS during follow-up where there is antimicrobial resistance or change of infective microbial agents.[4,5]

The US Centre for Disease Control and Prevention (CDC) introduced a required component of surveillance for SSI called PATOS in 2015.[6] However, the American College of Surgeons started collecting data on PATOS as early as 2011.[7] In the COSECSA region, we are not aware of hospitals or facilities that have collected and analyzed the PATOS rates and how these affect the rates of SSI in patients with PATOS.[8] We believe this is the first study to document this.

The study aimed to determine the SSI prevalence and antimicrobial resistance of patients with PATOS presenting to the 3 tertiary hospitals in the Copperbelt Province of Zambia.

Methodology

This was a cohort study. Patients who fulfilled the inclusion criteria of PATOS, were recruited. This study was conducted at 3

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tertiary hospitals: Ndola Teaching Hospital, Kitwe Teaching Hospital, and Arthur Davison Children's Hospital in the Copperbelt Province of Zambia. This study investigated development of superficial SSI, as defined by the World Health Organization (WHO), to be a postoperative infection that develops within 30 days after operation. Those participants that developed SSI had pus swabs collected and subjected to microscopy, culture and sensitivity (m/c/s).

Modified WHO Surgical Unit-based Safety Program surveillance forms were used. Designed data collection sheets were entered into Microsoft Excel for analysis. P-values were calculated using the chi-square test of independent variables using SPSS version 28. Dependent variable was development of SSI. Independent variables included ASA class of patient, skin preparation, antibiotic prophylaxis, surgical procedure, duration of surgery and use of drains or implants.

Procedure

All patients with PATOS were included in this study. The patients with clean and clean contaminated wounds were excluded. Patients with dirty or contaminated wound classes were defined as wounds with retained devitalized tissue and those with existing clinical infections or perforated viscera requiring surgical management. This definition suggests that the organisms causing infection were present in the operative field before the operation, and hence defined patients with PATOS. PATOS patients were followed for 30 days after discharge and surveillance information for those that developed SSI were recorded.

Informed consent was obtained from patients or guardians. Surveillance information was collected using WHO perioperative, postoperative and phone follow-up forms.

Ethics

Ethics approval covering the entire database as described in methodology, was obtained from the Tropical Diseases Research Centre Ethics Review Committee, with IRB registration number 00002911, and the National Health Research Authority.

Statistical analysis

Using SSPS version 26, descriptive analysis was performed using proportions and frequencies for categorical variables, means with standard deviations, and medians with interquartile ranges for skewed data. Associations of variables were analyzed using the chi-square test for categorical variables. Further analysis of the outcome was conducted using logistical regression.

Results

A total of 476 participants were included and of these, 297 were males and 179 were females. Baseline characteristics of patients enrolled in the study are shown below.

Basic characteristics of study participants

Age and gender of participants

In this study there were more males than females as shown in Figure 1. However, gender was not a risk factor for SSI, with a p-value of 0.319. The age distribution of the 516 participants who had PATOS showed that the majority (25.7%) were aged 21–30 years, followed by those aged 31–40 years (24%), with the smallest number aged 10 years and below (0.1%) as shown in Figure 2. However, age was not significant for the development of SSI, with a p-value of 0.319. This study found that 50.4% had dirty wounds while 49.6% had contaminated wounds as shown in Figure 3. However, development of SSI was not significant, with a p-value of 0.921.

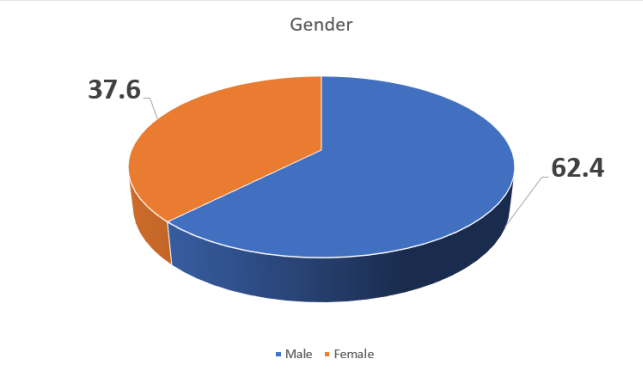

Figure 1 Gender of participants.

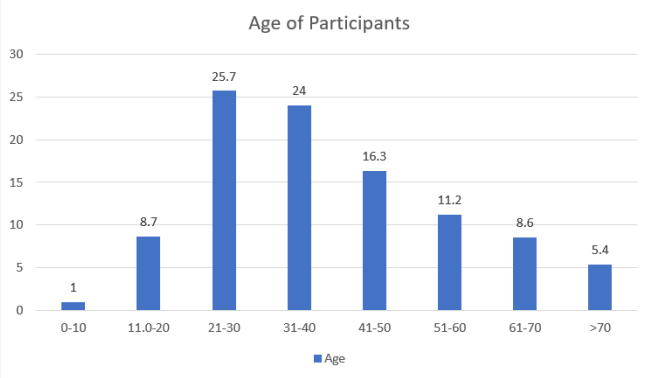

Figure 2 Participants' ages.

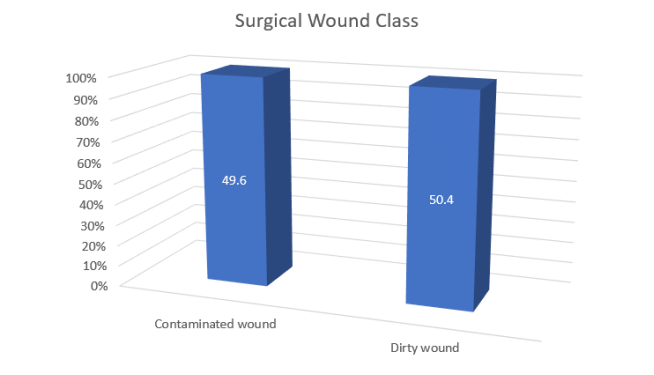

Figure 3 Surgical Wound Classifications.

Wound class categories

The top five (5) PATOS conditions were peritonitis (24%), cellulitis (20%), abscess (13%), wet gangrene (8.6%), and perianal abscess (3.4%) as shown in Table 1.

PATOS conditions included

A total of 117 (24.6%) out of 516 participants developed SSI during 30-day follow-up period after initial surgical and medical management of the PATOS they presented with on admission as shown in figure 4. 58 participants had contaminated wounds while 59 participants had dirty wounds. Therefore, this study determined prevalence of SSI after treatment of PATOS or community acquired

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infections to be 24.6%. The pus swab samples collected and submitted for m/c/s, during the 30-day follow-up period, identified the causative organism thereby confirming development of SSI.

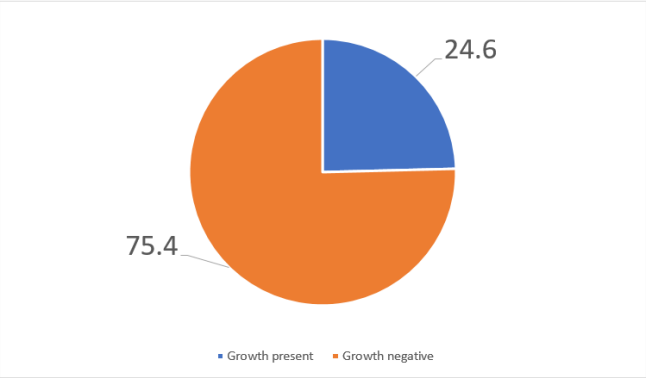

Figure 4 Pus swab samples of PATOS submitted for analysis.

Table 1 Conditions with PATOS

Diagnosis	Number of subjects
Necrotizing fasciitis	13
Complicated appendicitis	9
Uncomplicated appendicitis	21
Gastric perforation	12
Septic cyst	1
Tongue laceration	1
Hand infection	1
Bowel perforation	12
Bowel obstruction	19
Anastomotic leak	7
Otitis media	1
Neck space infection	9
Traumatic amputation	1
Gluteal abscess	1
Infected stump	1
Gas gangrene of limbs	1
Human bite	1
Infected Open fracture	1
Perianal abscess	16
Gluteal abscess	9
Decubitus ulcers	8
Cellulitis	104
Abscess	44
Pyomyositis	14
Wet gangrene of limbs	41
Degloving wound	8
Perianal fistula	13
Peritonitis	124
Ludwig's angina	14
Enterocutaneous fistula	9
Total	516

Prevalence of SSI in Patients with PATOS

The organisms isolated from the wounds of the participants that developed SSI after treatment of PATOS cultured organisms as shown in Table 2. The top 4 organisms isolated from those that developed SSI after treatment of PATOS were *S aureus* (26%), *E coli* (11%), *P aeruginosa* (11%), and *E agglomerans* (9%).

Table 2 Organisms Isolated from Subjects with PATOS During 30-day Follow-up for SSI

Organism	Frequency	Percentage (%)
Corynebacterium Species	29	6
Proteus Mirabilis	29	6
Escherichia Coli	54	11
Enterococcus Species	14	3
Yesnia Pestis	14	3
Proteus Species	19	4
Corynebacterium Diphtheriae	24	5
Enterobacter Agglomerans	44	9
Enterobacter Cloace	29	6
Klebsiella Pneumonia	17	6
Serratia Marcesceus	19	4
Pseudomonas Aeroginosa	53	11
Staphylococcus Aureus	131	26
Total	476	100

Microscopy and Culture Results of PATOS

The sensitivity and resistance profile results of SSI that developed after treatment of PATOS is shown in figure 5. Ciprofloxacin had the highest resistance, followed by azithromycin and penicillin. The highest sensitivity was to ceftriaxone and chloramphenicol, followed by metronidazole.

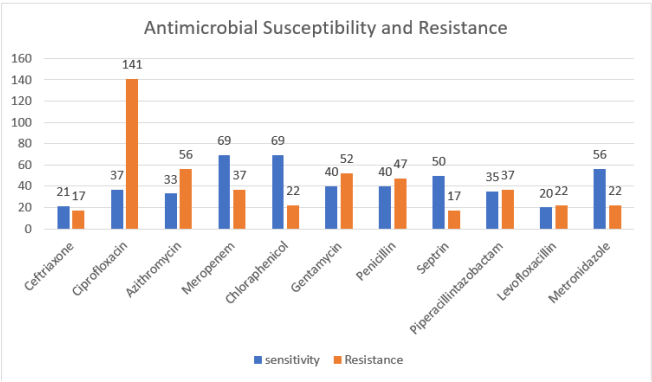

Figure 5 Susceptibility test results of patients with PATOS.

Susceptibility and anti-microbial resistance profile of cultured organisms

The resistance patterns of microorganisms that were cultured are shown in Table 3. Most bacteria isolates were resistant to ciprofloxacin, metronidazole, and gentamycin.

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Table 3 Top 10 microorganisms and their resistance patterns

No	Microbial organism	Highest resistance	Medium resistance	Lowest resistance
1	*S aureus*	Ciprofloxacin	Septrin	Chloramphenicol
2	*E coli*	Metronidazole	Ciprofloxacin	Levofloxacin
3	*K pneumoniae*	Ciprofloxacin	Penicillin	Piperacillin Tazobactam Gentamycin
4	*P mirabilis*	Metronidazole	Ciprofloxacin	
5	*P aeruginosa*	Ciprofloxacin	Piperacillin Tazobactam	Penicillin Azithromycin
6	*E cloaca*	Penicillin	Ciprofloxacin	Metronidazole
7	*S marcescens*	Levofloxacin	Ciprofloxacin	Meropenem
8	*Y pestis*	Gentamicin	Meropenem	Ciprofloxacin Septrin
9	*Corynebacterium* species	Gentamycin	Meropenem	
10	*E agglomerans*	Ciprofloxacin	Septrin	Piperacillin Tazobactam none

The were 3 multidrug-resistant (MDR) species, namely *S marcescens*, *Y pestis*, and *Corynebacterium* species as shown in Table 4. This finding may also be a limitation of the antibiogram used to check sensitivity; however, another study is required to validate this finding in this study.[9]

Table 4 Top 10 Microorganisms and Their Sensitivity Patterns

No	Microbial organism	First choice	Second choice	Third choice
1	*S aureus*	Ceftriaxone	Penicillin	Levofloxacin
2	*E coli*	Chloramphenicol	Gentamycin	Levofloxacin
3	*K pneumoniae*	Gentamycin	Chloramphenicol	None
4	*P mirabilis*	Chloramphenicol only	none	None
5	*P aeruginosa*	Chloramphenicol only	none	None
6	*E cloaca*	Chloramphenicol	Ceftriaxone	None
7	*S marcescens*	None (antibiogram limitation or multidrug-resistant)	None	None
8	*Y pestis*	None (antibiogram limitation or MDR)	None	None
9	*Corynebacterium* species	None (antibiogram limitation or MDR)	None	None
10	*E agglomerans*	Meropenem	Chloramphenicol	metronidazole

Most organisms were sensitive to ceftriaxone and Chloramphenicol as shown in Table 4. Table 4 also shows some organisms were multi-drug resistant and further studies are required to analyze these findings.

Discussion

This study found a 24.6% prevalence for superficial SSI in patients who are treated for PATOS after medical and surgical management and 30-day follow-up according to figure 4. It excludes those who had clean and clean-contaminated wounds. The overall prevalence of SSI for all wound classes at the three tertiary hospitals determined to be 19.4%, as part of the partially analyzed database used for this study.[10] Moono et al.[11] found overall SSI rate at Ndola Teaching Hospital to be 18%. This 24.6% rate is higher than the overall SSI estimated by WHO for low- and middle-income countries like Zambia; however, the WHO SSI rate does not isolate the prevalence rate of developing SSI after treatment of PATOS, and we could not find the WHO estimated rate for SSI that develops after treatment of PATOS, in a 30-day follow-up period, in low- and middle-income countries like Zambia.[9]

Olowo-Okere et al.[12] in their systematic review and meta-analysis found a prevalence of SSI in dirty wounds, in large samples from all developing countries that included sub Saharan African region analyzed, was 52.7% which is much higher than the prevalence found in this study. Bahru et al,[13] found a prevalence of 9.3% in postoperative wounds in their study.

The top 5 PATOS conditions included peritonitis (26%), cellulitis (21.8%), abscess (9.2%), wet gangrene (8.6%), and perineal abscess (3.4%) as shown in table 1. The majority of those who presented with PATOS in this study were males (62%), and the majority of the PATOS population were aged 31–40 years. These findings are similar to other studies conducted in the locality of the three tertiary hospitals.[10,11] The average age in Siedelman et al's (1) study was 54.2 years, and the majority were male. The average age was higher than for the patients in our study, but gender distribution matches.

The pus swabs culture results collected in PATOS patients who went on to develop SSI during the 30-day follow-up period, as indicated in Table 2, show that the top 4 microbes include S aureus (26%), E coli (11%), *P aeruginosa* (11%), and *Eagglomerans* (9%). Monk et al (14), reported similar results in their systematic review and meta-analysis where they reported the most cultured nosocomial bacteria in SSI, in their study, as *S. aureus* (29%), E. coli (14%), *K. pneumoniae* (11%), *P. aeruginosa* (14%).

Figure 5 shows that highest resistance was among ciprofloxacin, azithromycin, gentamycin and penicillin. The most isolated organisms and antibiotics with highest resistance patterns included

S. aureus (ciprofloxacin), E. coli (metronidazole), *P. mirabilis* (metronidazole) and *P. aeruginosa* (ciprofloxacin) as shown in Table 3. Table 4 shows most common isolates and their sensitivity which include *S. aureus* (ceftriaxone), *E. coli* (chloramphenicol), *P. mirabilis* (chloramphenicol) and P. aeruginosa (chloramphenicol). This study also found multidrug resistance for isolates that include *S. marcescens, Y. pestis* and Corynebacterium species, requiring more studies to be done on such organisms. Monk et al.[14] reported isolates with high resistance in their study, which included S. aureus (resistant to methicillin) and P. aeruginosa (imipenem and meropenem), and recommended that more studies should be designed to study these multidrug resistance organisms. More studies are required to establish the clinicopathology conditions these organisms cause, their morbidity and mortality rates, and sensitivity and AMR, including genetic typing of the resistance of these organisms individually.

Conclusion

The prevalence of SSI that develops in patients with PATOS during 30-day follow-up is 24.6% for the 3 tertiary institutions in the Copperbelt Province of Zambia. The top 4 organisms responsible for SSI after PATOS is treated include *S aureus*, *E coli*, *P aeruginosa*, and *E agglomerans*. The top 3 resistant antimicrobials include ciprofloxacin, metronidazole, and gentamycin, while sensitivity to chloramphenicol and ceftriaxone was shown. This study discovered 3 MDR microbes requiring follow-up studies.

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Conflicts of Interest

The authors declare that there are no conflicts of interest

Funding

None

Ethics approval

Ethics approval was obtained from the Tropical Diseases Research Centre Ethics Review Committee with IRB registration number 00002911 and National Health Research Authority.

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