



Surgical Site Infection at a Central Academic Hospital in Johannesburg: A One-year Audit

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Abstract: *Introduction:* Surgical site infection accounts for approximately 38% of hospital-acquired infections globally and is associated with increased length of hospitalization and mortality. The aim of the study was to determine the incidence of surgical site infection, causative organisms and factors which were associated with its occurrence at a central hospital in South Africa. *Methods:* A retrospective review of records of patients who developed surgical site infection over a 12-months period was conducted. Data were extracted from records of weekly morbidity and mortality meetings of the Department of Surgery. Data retrieved included demographic information, co-morbidities, nature of surgery, class of surgical site infection and microscopy, culture and sensitivity results and overall outcome including the length of hospital stay. *Results:* During the study period 3 005 surgical procedures were performed of which 46.8% were elective operations. A total of 147 records of patients who developed surgical site infection were found. The mean age of these 147 patients who developed surgical site infection was 47.3±17.21 years. The incidence of reported surgical site infection was 4.8% (147/3 005) with 72.6% (93/147) occurring in males. Nineteen of the 147 cases had to be excluded and thus only 128 patient files were suitable for the study. Of patients who developed surgical site infection, 30.5% (39/128) had diabetes mellitus, 21.9% (28/128) had hypertension and 18.8% (24/128) had both diabetes and hypertension, while 15.6% (20/128) of patients were known to be HIV positive. Sixty-four percent (64.1%: 82/128) of the patients who developed SSI had positive culture results and the two most commonly cultured organisms were *E. coli* (44%, 36/82) and *P. aeruginosa* (29.3%, 24/82). *Conclusion:* The overall rate of occurrence of surgical site infection was 4.8% and most of the infections were diagnosed in male patients. The two most commonly cultured organisms were *E. coli* and *P. aeruginosa*. Thirty-one percent who had surgical site infection had diabetes mellitus.

Keywords: Surgical Site Infection, Classification, Co-morbidities, Diabetes Mellitus, Gender, HIV

1. Introduction

Surgical site infection (SSI) is an infection of the skin, soft tissues, organs or anatomical spaces following an invasive procedure. Included are infections, which occur within 30 days following the procedure and even up to a year if the operation included insertion of a prosthetic device if an implant is in place. The definition of SSI does not include burn wounds, circumcision, episiotomies or stitch abscesses.

Surgical site infections account for approximately 38% of all hospital acquired infections globally [1]. Surgical site

infection is the most commonly reported type of nosocomial infection globally, and accounted for 19.6% of all nosocomial infections in Europe in 2011-2012, which was higher than the rate of pneumonia and urinary tract infections at 19.4% and 19.0%, respectively [2]. Seventy-five percent of the mortalities in patients who develop SSI are directly related to the SSI [3].

Surgical site infection is classified into incisional and organ or space infections [1]. A sub-classification of incisional site infection is superficial SSI i.e. an infection which is limited to skin and subcutaneous tissue [1]. Risk factors of SSI are divided into patient-related (preoperative),

procedure-related (perioperative), and postoperative categories. The patient-related risk factors for SSI are categorized as either modifiable or non-modifiable [2]. The modifiable factors include diabetes mellitus, obesity, smoking and length of preoperative hospitalization [1]. An example of a non-modifiable risk factor for SSI is the age of a patient. Among the risk factors which are related to the operation is the class of a surgical wound, organ site and the length of surgery. Some of the postoperative risk factors for SSI are blood transfusion and poor glycaemic control [2].

Surgical site infection is frequently associated with increased morbidity, mortality and length of hospital stay. The development of SSI increases the clinical and financial burden of surgery. Surgical site infection increases the work load of the healthcare professionals and has a negative impact on patient outcome [2]. The economic impact of SSI is mainly due to an increase in the length of hospitalization, additional diagnostic tests, antimicrobial use and dressings [2]. Reoperation is necessary in some of the patients who develop SSI [2]. Badia and colleagues showed that patients who developed SSIs incurred twice the medical cost compared to patients who did not develop SSIs [2]. In the same study, Badia and team showed that the length of stay of patients who developed SSI was double the number of days of patients who did not develop SSI.

The reported rate of occurrence of SSIs in sub-Saharan Africa ranges from 6.8% to 26% [4]. The aim of this study was to determine the rate of occurrence of SSI at a tertiary academic hospital in the Gauteng Province of South Africa. Furthermore, the factors which were prevalent in patients who developed SSI, were studied.

2. Methods

Permission to conduct the study was obtained from the Human Research Ethics Committee of the University of the Witwatersrand (M180945) and the CEO of Charlotte Maxeke Johannesburg Academic Hospital (CMJAH). This was a retrospective observational study based on a one-year audit of patients' records of the weekly morbidity and mortality (M+M) meetings of the Department of Surgery. The M+M data are stored on the Research Electronic Data Capture (REDCap) platform. Postoperative complications captured on REDCap are classified using the modified Clavien-Dindo classification of postoperative complications [5]. Additional information was obtained from theatre records, patients' files and microbiology results. Data retrieved included demographic information, co-morbidities, nature of surgery, class of SSI and microscopy, culture and sensitivity (MC & S) results, and overall outcome including the length of hospital stay.

The records of all patients who were operated on at CMJAH and subsequently developed SSI during the study period between the 1st of July 2017 and the 30th of June 2018, were reviewed. The patients included in the study were the individuals who were confirmed by the surgical units during the M+M meeting to have developed SSI. Records of patients who were re-admitted for SSI following an operation before

the study period, patients on immune-suppressants, patients whose records were incomplete and patients with infection of another area not related to the area of operation e.g. urinary tract infection (UTI), were excluded from the study.

The study was conducted following the principles which are contained in the Declaration of Helsinki. Informed consent was waived as it was a retrospective study. Each case was given an individual study number without recording any personal identifiers. Information was transcribed from the anonymous patient data collection sheet to an Excel spreadsheet using the patient's study number only. A separate list of patient study numbers with patient identifiers recorded was kept in a safe and user name protected electronic file, only accessible to the principal investigator, to ensure anonymity of the patients.

Data was analysed using the statistical programme Stata v13.1 (College Station, Texas). Continuous data were summarized by using the mean and standard deviation when data were normally distributed, and the median and inter-quartile range (IQR) when the data were not normally distributed as determined by using the Shapiro Wilk test for data distribution. The paired t-test was used for comparison of findings with normally distributed continuous data, and the Wilcoxon signed rank test if not normally distributed. Categorical findings were comparatively analysed by calculating frequency and percentage and using the Chi-square test and the Fisher's exact test. The level of significance was set at a p-value <0.05.

3. Results

A total of 147 cases of SSI among 3005 surgeries were recorded in REDCap over a one-year period. Less than half, 1 406 (46.8%) of the operations were elective operations. The rate of SSI was 4.8%. The mean age of the patients who developed SSI was 47.3±17.21 years. Of these 147 cases, two patients had a kidney transplant and were on immune-suppressants, and hospital files for 17 patients could not be traced, thus 19 of the 147 cases were excluded. Of the remaining 128 patients, 72.7% (96/128) of the reported cases were in males. Eighty-one (63.3%: 81/128) of the SSIs developed in patients who had emergency surgical procedures. Approximately 44.5% (57/128) the SSIs were superficial SSIs (Table 1).

Table 1. Patient demography, number of co-morbidities and type of SSIs (n=128).

Parameter	Finding (%)
<i>Nature of Surgery</i>	
Emergency	81 (63.3%)
Elective	47 (36.7%)
Emergency to Elective Ratio	1.72:1
<i>Gender</i>	
Male	93 (72.7%)
Female	35 (27.3%)
Male to Female Ratio	2.66:1
<i>Mean age</i>	47.3±17.21 years.
<i>Associated co-morbidities</i>	
Yes	111 (86.7%).
No	17 (13.3%).
<i>Types of SSI</i>	

Parameter	Finding (%)
Superficial	57 (44.5%).
Deep	15 (11.7%).
Organ space	56 (43.8%).

Out of the total of 3005 patients the rate of occurrence of SSI in elective cases was 5.1% (81/1 599) and in emergency patients it was 3.3% (47/1 406). Among the patients who developed SSI, 30.5% (39/128) had diabetes mellitus, 21.9% (28/128) had hypertension and 18.8% (24/128) had both diabetes and hypertension while 15.6% (20/128) were known to be HIV positive. The mean pre-operative body temperature in patients who developed SSI was $37.2 \pm 0.36^\circ\text{C}$ compared to $37.7 \pm 0.35^\circ\text{C}$ post-operatively, and the difference was statistically significant (Table 2).

Table 2. Pre-operative and post-operative clinical and laboratory findings in patients who developed SSI (n=128).

Parameter	Findings		
	Pre-operative	Post-operative	p-value
Mean body temperature	$37.2 \pm 0.36^\circ\text{C}$	$37.7 \pm 0.35^\circ\text{C}$	0.0150
Mean white cell count	11.3 ± 5.9	18.5 ± 8.6	0.0010
Mean CRP	86.1 ± 11.8	229.5 ± 111.1	< 0.00001
Mean blood glucose	9.6 ± 3.1	11.9 ± 3.9	0.0042

Of the patients who developed SSI 45.3% (58/128) had open surgical interventions whereas a percutaneous drainage was done in 10.2% (13/128). Only one patient who developed SSI was treated with intravenous (IV) antibiotics alone (Table 3).

Table 3. Options in the management of patients who developed SSI (n=128).

Intervention	Number (%)	Cumulative %
Relook procedure	58 (45.3%)	45.3%
Removal of stitches or clips	47 (36.7%)	82.0%
Percutaneous drainage	13 (10.2%)	92.2%
Debridement	5 (3.9%)	96.1%
Wound irrigation	3 (2.3%)	98.4%
Wound dressings	1 (0.8%)	99.2%
Intravenous antibiotics only	1 (0.8%)	100%

Sixty-four percent (64.1%: 82/128) of the patients who developed SSI had positive microscopy culture and sensitivity (MC&S) results. In 28.1% (36/128) of the cases culture results showed *E. coli* (Table 4).

Table 4. Organisms isolated from MC&S in patients who developed SSI (n=82).

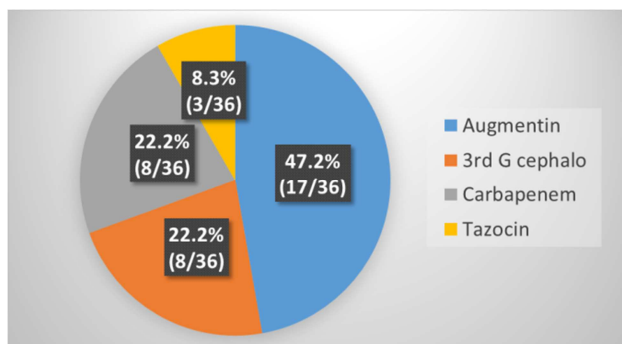
Organism	Number (%)
<i>E. coli</i>	36 (43.9%)
<i>P. aeruginosa</i>	24 (29.3%)
<i>K. pneumoniae</i>	12 (14.6%)
<i>S. aureus</i>	11 (13.4%)
<i>A. baumannii</i>	8 (9.7%)
<i>E. faecium</i>	8 (9.7%)

Forty-one (32%: 41/128) of the MC&S results showed more than one organism. Colorectal procedures accounted for 45.1% (37/82) of the positive culture results. Of the colorectal procedures, 37.8% (14/37) of SSIs cultured were positive for *E. coli* (Table 5).

Table 5. Breakdown of organisms cultured in patients who developed SSI according to the type of operation.

Original surgical procedure	<i>E. coli</i>	<i>P. aeruginosa</i>	<i>S. aureus</i>	<i>A. baumannii</i>	<i>E. faecium</i>	<i>K. pneumonia</i>	<i>E. faecalis</i>
Laparotomy (40)	15	8	4	5	2	3	3
Colorectal (37)	14	6	1	2	3	7	4
Vascular (6)	2	2	1	-	1	-	-
Amputation (5)	-	2	-	1	-	1	1
Hernia (4)	-	2	1	-	-	1	-
Breast (4)	-	1	3	-	-	-	-
Appendi-ectomy (3)	2	1	-	-	-	-	-
Other (3)	3	1	-	-	-	-	-

Seventeen (47.2%: 17/36) of the *E. coli* cultures were sensitive to amoxicillin/clavulanic acid (Augmentin) while 22.2% (8/36) were sensitive to 3rd generation cephalosporins (Figure 1).



*Tazocin=Piperacillin/Tazobactam

Figure 1. Antibiogram for *E. coli* species cultured from patients who developed SSI (n=36).

Eleven (45.8%: 11/24) isolates of *P. aeruginosa* were sensitive to piperacillin/tazobactam (Tazocin) (Figure 2).

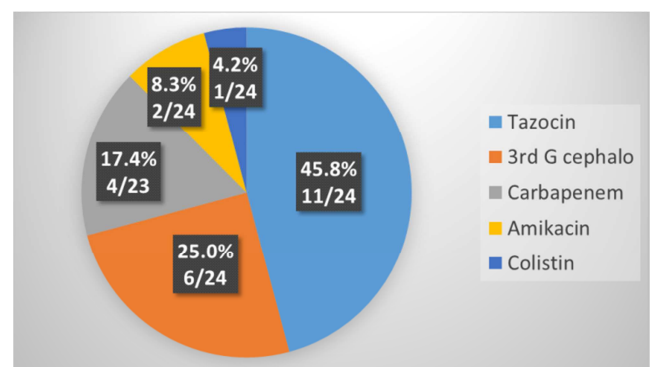


Figure 2. Antibiogram of *P. aeruginosa* species cultured from patients who developed SSI (n=24).

In the case of *K. pneumoniae*, three strains 25% (3/12)

were susceptible to amikacin, 16.7% (2/12) to Tazocin and imipenem, and 8.3% (1/12) each to cefepime, colistin, Augmentin, ertapenem and ceftriaxone. In the case of *S. aureus* 72.7% (8/11) strains were susceptible to cloxacillin while 27.3% (3/11) were sensitive to vancomycin.

Two (25%; 2/8) of the *A. baumannii* strains showed sensitivity to colistin. The rate of sensitivity of *A. baumannii* strains to the other antimicrobials is shown in Figure 3.

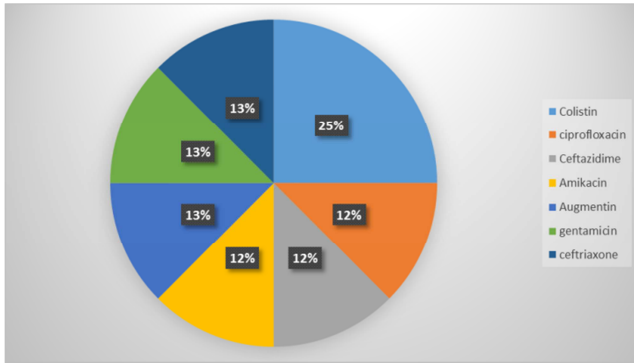


Figure 3. Antibigram of *A. baumannii* species cultured from patients who developed SSI ($n=8$).

Sixty-three (49.2%; 63/128) of the patients who needed at least one surgical intervention, 10% (13/128) had a pigtail for intra-abdominal collections. The median of the length of hospital stay was 18 days, with no difference between different types of wounds. The length of stay was 22 days among the patients who developed organ/space SSI. Two patients (1.6%; 2/128) who developed SSI died and 28% (36/128) required re-admission.

4. Discussion

This study revealed a rate of SSIs of 4.8%, which is comparable to the incidence of SSIs reported by Nair *et al.*, in the Northern Cape Province of South Africa [6]. The relatively low rate of SSI in South Africa is like figures reported in Norway (4.6%) [7] and Switzerland (4%) [8]. In contrast, the rate of occurrence of SSI across the African continent is high. For example the rate of SSI which was reported from Nigeria ranged from 15 to 27% [9, 10] while from Ethiopia 19.1% [11, 12] and in Tanzania 26.0% [13]. However, the SSI reported rates from countries across the world may not be comparable as patients' attributes, wound classifications, definition and diagnostic approach could have been different.

A higher rate of occurrence of SSI in patients younger than 40 years is not different to findings from prior studies [14]. Two-thirds of the patients in our study developed SSI after elective surgical interventions, which may have influenced the results. The rate of occurrence of SSI is also influenced by the nutritional status of a patient, the level of immunity and comorbid illnesses such as HIV/AIDS or diabetes mellitus [15-18].

Patients with SSIs are much more likely to spend extra days in the clinic/hospital opposed to patients without SSIs.

This observation is in line with a number of other reports [2, 19-21]. The mean length of hospital stay in this study was 18 days, which is within the ranges found in other studies of 3 to 23 days. Our finding is like the 19 days reported by Whitehouse and colleagues in 2002 [22].

The present study retrospectively analysed the level of the WCC and CRP regarding their sensitivity and specificity for detecting perioperative infections. Regardless of the type of operation or the type of SSI that developed, the study showed a 100% increase in CRP while the WCC was only elevated to 85.1%. Similar findings were reported in two prior studies [23, 24]. The elevation of CRP is however not always due to an infection. Although the procalcitonin test (PCT) is commonly used as a diagnostic marker of sepsis [25] and has been confirmed to be a more accurate marker for the recognition of early postoperative infection after cardiac and intestinal surgeries compared with standard laboratory parameters, such as CRP and WBC [26], in this current study the WCC and CRP were still used as indicators of infection.

In this current study approximately 44% of SSIs were classified either as superficial or organ/space SSIs, while most other studies revealed that superficial SSIs are the most frequently occurring type [27]. In contrast, results found by Poulsen *et al.*, indicated that more than 30% of SSIs are organ/space SSIs [28].

The most common microorganisms cultured in this study were gram-negative bacteria and these results are like a study done by Golzarri and colleagues in a 7-year retrospective review [29], while most of the other studies revealed a predominance of gram-positive microorganisms as the main cause of SSI [29-32].

Of importance is that this study provides standard information on the event of SSIs at the hospital and it may serve as a helpful tool in decision making and in assigning restricted funds in addressing SSIs and hospital acquired infections in general.

Limitations of the study

As a retrospective study, it lacked the comparison of a control group. A cause-and-effect relationship could not be determined. The study relied on the quality of documentation, and sometimes doctors and/or nurses do not report all the surgical site infections. Furthermore, complications sometimes occur on discharge and are not noticed at the Out Patients Department. Patients not returning to our hospital but going to another hospital for whatever reason, may also have impacted on our study. Another but substantial limitation was that it was only a one-year study at one hospital.

5. Conclusion

The overall rate of SSI in the surgical patients was 4.8%. The majority of SSIs occurred in males. The two most commonly cultured organisms in patients who developed SSI were *E. coli* and *P. aeruginosa*. Thirty-one percent of patients who were diagnosed with SSIs had diabetes mellitus. The study provides a baseline for annual quality improvement program. Follow-up studies should be

conducted to map the change in the prevalence of SSI and the antibiogram of causative organisms.

Author Contribution Statement and Agreement of Co-authors

Herewith all four authors declare that each author had made a significant contribution to this manuscript as detailed below, have seen and approved the final manuscript and have agreed to its submission to your journal.

BMKE: Execution of research work, collection and analysis of data, drafting the manuscript, final corrections and approval of the final manuscript.

MA: Clinical supervision of project and final approval of the manuscript.

LTE: Original study idea, conceptual design, clinical supervision and final approval of the manuscript.

NM: Research design, academic supervision, final writing, proofreading and editing of the manuscript.

Conflict of Interest

All authors have no conflict of interest to declare.

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