Incidence and Microbiology of Surgical Site Infection Following Hysterectomy at a South African Quaternary Hospital

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Abstract

Background: Data from high-income countries suggest that surgical site infection (SSI) is an important cause of morbidity following hysterectomy, with a reported incidence of 2.7%. SSI is also associated with increased healthcare resource utilization. Reports of SSI following hysterectomy in African settings are rare, limiting our setting-specific understanding of this complication.

Objectives: To determine the incidence and microbiology of SSI following hysterectomy at a South African quaternary hospital.

Patients and Methods: This is a retrospective cohort study of 563 hysterectomy patients who attended a South African quaternary hospital between 1 January 2012 and 31 July 2016. We collected data on patient age, comorbidity, surgery-related variables, and postoperative length of stay from the hospital's administrative database and a retrospective chart review. Our study outcome was SSI up to 30 days postoperatively. SSI data was obtained from the hospital's diagnostic laboratory. We calculated the cumulative incidence of SSI, and also performed descriptive and bivariate statistical analyses.

Results: The cumulative incidence of SSI was 2.8%. Patients with SSI had a longer postoperative length of stay (p<0.001), underwent surgery via the laparotomy approach (p=0.009), or had wound closure with the simple mattress approach (p=0.015). Infection with *Pseudomonas aeruginosa*or atypical microorganisms was common.

Conclusion: SSI contributes to morbidity and increased healthcare resource utilization following hysterectomy in our setting. The decision to choose the approach for hysterectomy should consider the higher risk of SSI associated with the laparotomy approach and interrupted suturing. SSIs with atypical microorganisms present a challenge for patient management in our setting.

Keywords: Surgical site infection; Incidence; Microbiology; Hysterectomy**.**

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Introduction

Hysterectomy remains one of the most commonly performed surgical procedures throughout the world **(Hammer et al., 2015)**. It is used to treat a variety of gynaecologic conditions affecting the female reproductive tract, including benign disease, preinvasive disease, invasive disease, and acute conditions(**Lefebvre et al., 2002)**.Surgical intervention is often not without risk, and a proportion of women undergoing hysterectomy will likely suffer a postoperative complication. Surgical site infection (SSI) is one of the most frequently encountered complications following gynaecologic surgery **(Erekson et al., 2011)**. An analysis of high-quality patient data collected as part of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), found that the overall incidence of SSI in a cohort of 13822 hysterectomy patients was 2.7% **(Lake et al., 2013)**. Gram-negative bacilli, enterococci, group B streptococci, or anaerobes werethe most frequently encountered microorganisms isolated from the infected surgical wounds of women who had undergone gynaecologic procedures(**Mangram et al., 1999)**.In addition to its impact on postoperative morbidity in patients undergoing hysterectomy, evidence from high-income countries shows that SSI also increases postoperative length of stay and thus has implications for healthcare resource utilization in these settings(**Mahdi et al., 2014; Morgan et al., 2016**).

Surgical approaches to hysterectomy have advanced since the first procedures were performed in the1800's **(Sutton, 1997)**, and now there are three broad surgical approaches to consider: Laparoscopic(**Einarsson and Suzuki, 2009**), vaginal(**Veronikis, 2015**), and laparotomy(**Hiramatsu, 2019**). The aforementioned ACS-NSQIP analysis conducted by Lake et al., found that the odds of SSI varied according to the surgical approach used(**Lake et al., 2013)**. More specifically, Lake et al., observed that the odds of superficial SSI in patients who had hysterectomy via the laparotomy approach was almost four-fold higher than patients who had hysterectomy via the vaginal approach(**Lake et al., 2013**). The odds of superficial SSI were found to be similar in patients who had hysterectomy via the vaginal and laparoscopic approaches **(Lake et al., 2013)**.

South African women currently face several reproductive health challenges, including HIV infection and cancer **(Sathiya Susuman, 2018)**. Accordingly, up to 13.4% of surgeries performed in the country each week were gynaecologic procedures(**Biccard and Madiba, 2015**). However, South African studies which have sought to describe the incidence and microbiology of SSI following hysterectomy were rare. This dearth in the setting-specific knowledge hinders our efforts to prevent and treat SSI in South African patients undergoing hysterectomy. Knowing the incidence of SSI in women undergoing hysterectomy via each of the three surgical approaches would allow us to stratify SSI risk according to surgical approach. Women undergoing surgery via a high-risk approach could then be targeted for additional preventative measures. Improved knowledge of the microorganisms implicated in SSI following hysterectomy could be used to improve clinical decision-making related to antibiotic selection in our setting. Given the important implications of this knowledge for the management of hysterectomy patients in South Africa, we sought to address the paucity in the literature around SSI incidence and microbiology in this surgical population.

Patients and methods

Study design and location

We conducted a retrospective cohort study of hysterectomy patient data from the Inkosi Albert Luthuli Central Hospital (IALCH) in Durban, South Africa. IALCH is an 850-bed government-funded hospital which provides specialist medical and surgical services to the population of the KwaZulu-Natal Province and part of the Eastern Cape Province, South Africa.

Study sample

Our study sample consisted of 563 consecutive patients aged >18 years old who underwent hysterectomy at IALCH between 1 January 2012 and 31 July 2016. All eligible patients were identified from the operating room schedules at IALCH during the study period.

Data source

The patient's age, the surgical approach used, the duration of the surgery, and postoperative length of stay were extracted directly from the IALCH electronic administrative database system. We also performed a retrospective chart review of the patient medical records and collected data on comorbidity, indication for surgery, previous laparotomy scar, antibiotic prophylaxis receipt, intraoperative adhesions, suture material, and whether a simple mattress closure was used. Our study outcome was SSI. The Centres for Disease Control definition of SSI was adopted in our research(**Mangram et al., 1999**). Under this definition, SSI requires evidence of clinical signs and symptoms of infection and does not rely solely on microbiological evidence of infection. Clinical signs and symptoms of SSI include swelling and redness around the surgical site, pain at the surgical site, pus, fever, wound dehiscence, or histopathological/radiological evidence of infection(**Mangram et al., 1999**). It is standard of care at IALCH that patients in whom SSI is clinically suspected have a pus swab taken from their surgical wound, which is then sent to the hospital's diagnostic laboratory for microbiological testing. Therefore, all patients in our study who had pus swabs recorded were considered SSI cases. Microbiology testing data, including evidence of pus swab orders and microbiological culture results, were obtained from the diagnostic laboratory at IALCH. We measured SSI from the date of surgery until 30 days postoperatively. All study data were maintained in a de-identified, password-protected electronic spreadsheet.

Statistical analysis

We used R version 3.6.2 (R Foundation, Vienna, Austria) to conduct our statistical analyses. After importing the electronic spreadsheet containing our study data into the R statistical software package, the first step in our analysis plan involved conducting a descriptive statistical analysis to summarize the characteristics of our study sample. This was done by calculating medians and interquartile ranges (IQR) for continuous variables, and frequencies and percentages for categorical variables. We then calculated the cumulative incidence of SSIvia the traditional epidemiologic approach, using the number of patients with SSI as the numerator and the total number of patients in the study sample as the denominator. This result was multiplied by 100, to yield the cumulative incidence of SSI in our study sample as a percentage. We used descriptive statistics to calculate the median time to SSI in afflicted patients. A bivariate statistical analysis (Mann-Whitney U Test for continuous variables and the Fisher's Exact Test for categorical variables) was used to compare the characteristics of patients with and without SSI. Statistical significance in the bivariate analysis was set at $p<0.050$.Lastly, descriptive statistics were used to determine the most frequently isolated microorganisms from pus swab cultures.

Ethical consideration

This study was approved by the University of KwaZulu-Natal Biomedical Research Ethics Committee (Protocol BREC/00002523/202).

Results

Our study sample (N=563 patients) is described in (**Table 1**). The median age was 52.0 (IQR: 43.0-63.0) years. The most common comorbid condition was hypertension (232 patients, 41.2%). The most common surgical approach was laparotomy (324 patients, 57.5%). All laparotomies were performed with a standard midline incision method. Most surgeries were performed for cancer (179 patients, 31.8%). A total of 61 patients (10.1%) had a previous laparotomy scar. The majority of patients in this study received antibiotic prophylaxis (445 patients, 79.0%). Intraoperative adhesions were reported in 77 patients (13.7%). The median duration of surgery was 110.0 (IQR: 85.0-140.0) minutes, and the median postoperative length of stay was 4.0 (IQR: 3.0-5.0) days. Vicryl sutures were the most frequently used material for wound closure (272 patients, 48.3%). Closure of the surgical wound was performed using the simple mattress approach in 56 patients (9.9%). Of the 563 patients comprising our study sample, 16 suffered SSI within 30 days following surgery (Cumulative incidence of 2.8%). All SSIs recorded in this study were superficial SSIs. In the 16 patients who suffered SSI, the median time to infection was 9.5 (IQR: 4.0-13.3) days.

Table 1. Description of the study sample

Characteristic	Summary statistic
Age in years	
• Median (IQR)	52.0 (43.0-63.0)
Comorbidity and general condition	
• BMI in Kg/m^2 – Median (IQR)	30.8 (26.1-35.7)
• Haemoglobin in g/dL – Median (IQR)	12.1 (10.9-13.1)
• Diabetes, n (% of N=563)	87 (15.5)
• Hypertension, n (% of N=563)	232 (41.2)
• Cardiac disease, n (% of N=563)	54 (9.6)
• HIV, n (% of N=563)	120 (21.3)
Indication for surgery	
• Bleeding, n (% of N=563)	18 (3.2)
• Cancer, n (% of N=563)	179 (31.8)
• Fibroids, n (% of N=563)	102 (18.1)
• Other reason, n (% of N=563)	178 (31.6)
• Prolapse, n (% of N=563)	86 (15.3)

Previous laparotomy scar	
• No, n (% of N=563)	502 (89.2)
• Yes, n (% of N=563)	61 (10.8)
Antibiotic prophylaxis	
• No, n (% of N=563)	118 (21.0)
• Yes, n (% of N=563)	445 (79.0)
Surgical approach	
• Laparoscopic, n (% of N=563)	118 (21.0)
• Vaginal, n (% of N=563)	121 (21.5)
• Laparotomy, n (% of N=563)	324 (57.5)
Intraoperative adhesions	
• No,n (% of N=563)	486 (86.3)
• Yes, n (% of N=563)	77 (13.7)
Surgical duration in minutes	
• Median (IQR)	110.0 (85.0-140.0)
Suture material	
• Monocryl, n (% of N=563)	66 (11.7)
• None, n (% of N=563)	29 (5.2)
• Nylon, n (% of N=563)	41 (7.3)
• Other material, n (% of N=563)	155 (27.5)
• Vicryl, n (% of N=563)	272 (48.3)
Simple mattress closure	
• No, n (% of N=563)	507 (90.1)
• Yes, n (% of N=563)	56 (9.9)
Postoperative length of stay in days	
• Median (IQR)	4.0 (3.0-5.0)
Study outcome	
• SSI, n (% of N=563)	16 (2.8)

We present a statistical comparison of characteristics between the SSI and no-SSI groups in (**Table 2**). The median postoperative length of stay was 4.5 days longer in the SSI group when compared with the no-SSI group (p<0.001). With regard to surgical approach, there was a significantly higher proportion of patients who underwent laparotomy in the SSI group versus the no-SSI group (93.8% versus 56.5%, p=0.009).We also observed a higher proportion of patients who had their wounds closed using the simple mattress approach in the SSI group versus the no-SSI group (31.2% versus 9.3%, p=0.015).We did not observe statistically significant associations between any of the other variables investigated in this study and SSI.

Table 3 shows a list of microorganisms isolated from the 16 SSIs observed in our study sample. *Pseudomonas aeruginosa*was the most frequently isolated microorganism (4 SSIs, 25.0% of all SSIs in our study). Another important finding from the microbiological culture analysis was the high number of culture-negative SSIs (4 SSIs, 25.0% of all SSIs in our study).

Table 2. Statistical comparison of characteristics between SSI and no-SSI groups in our study

Characteristic	SSI (N=16)	No SSI (N=547)	p-value
Age in years			
• Median (IQR)	49.5 (41.5-65.3)	52.0 (43.0-63.0)	0.976
Comorbidity and general condition			
• BMI in Kg/m^2 – Median (IQR)	32.4 (29.2-38.7)	30.8 (25.9-35.7)	0.215
• Haemoglobin in g/dL – Median (IQR)	11.5 (10.2-13.0)	12.1 (11.0-13.0)	0.407
• Diabetes, n (% of N)	4 (25.0)	83 (15.2)	0.289
• Hypertension, n (% of N)	6 (37.5)	226 (41.3)	0.804
• Cardiac disease, n (% of N)	3 (18.8)	51 (9.3)	0.191
• HIV, n (% of N)	1 (6.3)	119 (21.8)	0.214
Indication for surgery			
• Bleeding, n (% of N)	1 (6.3)	17 (3.1)	0.267
• Cancer, n (% of N)	7 (43.7)	172 (31.4)	
• Fibroids, n (% of N)	2 (12.5)	100 (18.3)	
• Other reason, n (% of N)	6 (37.5)	172 (31.5)	
• Prolapse, n (% of N)	0 (0.0)	86 (15.7)	
Previous laparotomy scar			
• No,n (% of N)	12 (75.0)	490 (89.6)	0.084
• Yes,n (% of N)	4 (25.0)	57 (10.4)	
Antibiotic prophylaxis			
• No,n (% of N)	5 (31.2)	113 (20.7)	0.347
• Yes,n (% of N)	11 (68.8)	434 (79.3)	
Surgical approach			
• Laparoscopic, n (% of N)	0 (0.0)	118 (21.6)	***0.009***
• Vaginal, n (% of N)	1 (6.2)	120 (21.9)	
• Laparotomy, n (% of N)	15 (93.8)	309 (56.5)	
Intraoperative adhesions			
• No,n (% of N)	13 (81.2)	473 (86.5)	0.470
• Yes,n (% of N)	3 (18.8)	74 (13.5)	
Surgical duration in minutes			
• Median (IQR)	115.0 (109.0-146.2)	110 (85.0-140.0)	0.136
Suture material			
• Monocryl,n (% of N)	3 (18.8)	63 (11.5)	0.157
• None,n (% of N)	0 (0.0)	29 (5.3)	
• Nylon,n (% of N)	2 (12.5)	39 (7.1)	
• Other material,n (% of N)	7 (43.7)	148 (27.1)	
• Vicryl,n (% of N)	4 (25.0)	268 (49.0)	
Simple mattress closure			
• No,n (% of N)	11 (68.8)	496 (90.7)	***0.015***
• Yes,n (% of N)	5 (31.2)	55 (9.3)	
Postoperative length of stay in days			
Median (IQR)	8.5 (5.8-18.5)	4.0 (3.0-5.0)	***<0.001***

Table 3. Microbiology of SSI in our study

Microorganism	n (% of N=16)
Acinetobacter baumanni	2 (12.5)
Enterococcus faecalis	1 (6.3)
Klebsiella pneumoniae	1 (6.3)
Proteus vulgaris	1 (6.3)
Pseudomonas aeruginosa	4 (25.0)
Staphylococcus aureus	2 (12.5)
Staphylococcus epidermidis	1 (6.3)
Culture-negative SSI (Atypical microorganism)	4 (25.0)

Discussion

There were several key findings from our study. Firstly, we found that the cumulative incidence of SSI in our study sample of 563 South African hysterectomy patients was 2.8%. Secondly, we observed that SSI was associated with increased postoperative length of stay. Thirdly, we found that the laparotomy approach and wound closure using the simple mattress approach was associated with increased SSI. Lastly, the majority of SSIs were attributed to *Pseudomonas aeruginosa*or atypical microorganisms.

The cumulative incidence of SSI following hysterectomy in our South African study sample (cumulative incidence of 2.8%) is similar to that reported in a large American study which reported a cumulative SSI incidence of 2.7%(**Lake et al., 2013**). This suggests that SSI is an important postoperative complication among hysterectomy patients in both high-income and lower/middle-income countries. However, this does not mean that we should not strive to reduce SSI rates further in our setting, particularly as we found that SSI was associated with increased postoperative length of stay in our resource-constrained setting.

Studies from high-income countries have also reported increased postoperative length of stay in patients with SSI(**Broex et al., 2009; Mahdi et al., 2014; Morgan et al., 2016**). In these high-income settings, postoperative length of stay is deemed to be the most significant driver of healthcare expenditure(**Broex et al., 2009**). While economic studies of SSI in Africa are scarce, it can be inferred from the studies conducted in high-income countries that SSI would also contribute to a significant amount of additional healthcare expenditure in African settings through its association with increased postoperative length of stay. Thus, there is also a financial incentive to reduce SSIs in our resource-constrained setting. It is possible that a reduction in SSI incidence among hysterectomy patients in our setting could be achieved through reinforcement of the World Health Organisation's SSI prevention guidelines and other quality improvement initiatives.

Our finding regarding increased SSI in patients who underwent surgery via the laparotomy approach, when compared with the vaginal or laparoscopic approach, is congruent with the existing literature from both high-income countries(**Lake et al., 2013; Morgan et al.,**

2016).Laparotomy creates a large surgical incision(**Hiramatsu, 2019**), which presents an opportunity for microorganisms to breach the skin barrier and colonize the underlying tissues(**Maurer et al., 2019)**.In patients where the vaginal or laparoscopic approaches are contraindicated, the risk of SSI following surgery with the laparotomy approach should be communicated with the patient prior to surgery. Furthermore, new SSI preventative measures over and above those which are currently used as standard of care should developed and implemented in patients who undergo hysterectomy via the high-risk laparotomy approach. Our finding of increased SSI amongst patients who had wound closure performed via the simple mattress approach might be explained by the differences in long-term wound support provided by interrupted and continuous suturing methods. Interrupted suturing methods, such as the simple mattress approach, do not provide the same long-term mechanical support to the healing wound when compared with continuous suturing methods. Researchers from the Cochrane Collaboration found that the risk of superficial wound dehiscence was lower (Relative Risk: 0.08; 95% Confidence Interval: 0.02-0.35)following closure with continuous suturing methods when compared with interrupted suture methods**(Gurusamy et al., 2014)**.Wound dehiscence can provide an opportunity for microorganisms to colonize the surgical wound and cause SSI.

The high proportion of SSIs in our study which were attributed to *Pseudomonas aeruginosa* is unsurprising, as *Pseudomonas aeruginosa* falls in the category of gram-negative microorganisms which are frequently isolated from infected surgical wounds of patients who have undergone gynaecologic procedures(**Mangram et al., 1999**). Of great concern is the high proportion of culture-negative SSIs in our study which were attributed to atypical microorganisms. Culture-negative SSIs have important implications for patient diagnosis and management. Accurate identification of the microorganisms causing an infection is paramount for effective patient management, as it allows for the most appropriate antibiotic therapy to be selected**(Leekha et al., 2011)**. Our research suggests that it might be worth considering revisions to local clinical and diagnostic management algorithms around SSIs in high-risk gynaecologic surgery populations, such as hysterectomy patients.

The main strengths of our study were the large sample size and our comprehensive data on the microbiology of SSI. Our study also had limitations. Our study data was from a single, quaternary-level facility and our findings might not be completely generalizable to other hospitals in South Africa. In addition, we did not stratify our analysis according to the three SSI categories (Superficial, deep-incisional, and organ space SSI) proposed by the Centers for Disease Control **(Mangram et al., 1999)**, because all SSIs in our study were superficial SSIs. Despite these limitations, our study still provides useful epidemiological information on the incidence and microbiology of SSI which improves our understanding of this complication among hysterectomy patients in African settings.

Conclusion

We found that SSI is an important complication in South African patients undergoing hysterectomy. We confirm that SSI in this patient population not only has an impact on patient morbidity, but also has the potential to increase healthcare resource utilization and subsequent healthcare expenditure in our resource-constrained setting. The decision to choose the approach for hysterectomy should consider the higher risk of SSI associated with the laparotomy approach. Interrupted suturing should be carefully considered. Lastly, SSIs with atypical microorganisms present a clinical and diagnostic management challenge in our setting, which might necessitate revisions to local clinical and diagnostic management algorithms.

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