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ORIGINAL SCIENTIFIC REPORT

Surgical Site Infections in Emergency Abdominal Surgery at Tamale Teaching Hospital, Ghana

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Abstract

Background Surgical site infections (SSIs) result in delayed wound healing, increased use of antibiotics and increased length of hospital stay, putting remarkable physical and financial burden on patients, their relatives and the healthcare facilities. Patient-related factors, such as pre-existing colonization with antibiotic-resistant bacteria, and clinical-related factors, such as adherence to sterile techniques, contribute to the development of SSIs. The objective of this study, therefore, was to determine the SSI rate and risk factors for emergency abdominal surgeries at Tamale Teaching Hospital, Ghana.

Methods The study population was composed of patients undergoing emergency abdominal surgery at the Tamale Teaching Hospital between June 2010 and June 2015. Demographic and clinical data were collected and included, but was not limited to, patient age and sex, type of procedure performed, wound class (dirty or contaminated), receipt of perioperative blood transfusion, American Society of Anesthesiologists (ASA) score, presence of SSI, length of hospital stay and outcome of surgery. Standard multiple regression was used to statistically assess the independent variables for their association with SSI, and Pearson correlation coefficient was used to determine the strength of association. The beta (β) values, which had the greatest influence on the overall SSI, indicated the relative influence of the entered variable(s).

Results A total of 1011 patients underwent various emergency abdominal surgical procedures during the period of study. The β values were 0.008 for perioperative blood transfusion, 0.050 for sex, − 0.048 for ASA risk, − 0.001 for having health insurance, 0.037 for being referred from another health facility and 0.034 for age. Sex was the most distinctive contributor to SSI, while perioperative blood transfusion showed the least influence. Sex and ASA score were the best predictors of SSI occurrence. The coefficients of the P values for wound class and serum haemoglobin level (g/dL) were 0.000 and 0.032, respectively. The outcome of surgery was significantly and strongly associated with overall SSI and vice versa ($r = 0.088$, $P < 0.01$ two-tailed).

Conclusion Sex, ASA score, perioperative blood transfusion, wound class and haemoglobin level can predispose to SSI.

Introduction

Surgery plays a vital role in health care worldwide. The last decade has seen significant increases in the surgical capacity of healthcare facilities in low- and middle-income countries (LMIC) [1, 2]. However, obtaining and analysing data on quality control measures in these countries are

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challenging, due to the lack of infrastructure which precludes comprehensive follow-up of patients after surgery.

In general, the most commonly used predictors of surgical outcome are the rates of surgical site infection (SSI), morbidity and mortality, as well as the length of hospital stay (LOS) and quality of life post-surgery [3, 4]. Unfortunately, these parameters are difficult to measure in LMIC because of limited resources, both human and technological, and difficulties in establishing and maintaining contact with post-operative patients after discharge from the hospital. The parameter of SSI itself causes significant morbidity and mortality after surgery; as such, it has been adopted as a quality control measure for surgery.

The risk factors for SSI are well studied and include contaminated and dirty wounds, duration of the operation, patient comorbidities, and the American Society of Anesthesiologists (ASA) score (a subjective assessment of the patient's overall health).

It has recently become recognized that injudicious use of antibiotics is common worldwide and occurs frequently in the sub-Saharan region of Africa. The pitfalls of this practice are evidenced by the emergence of numerous and diverse antibiotic-resistant microflora, which render antibiotics ineffective for SSI prophylaxis and treatment and which remains a particular threat to health care in the sub-Saharan countries such as Ghana [5]. More determinants of SSI from LMICs have not been found in the literature. This has necessitated the current study.

The objective of this study was to determine the rate of SSI occurrence at the Tamale Teaching Hospital (TTH) in patients who undergo emergency abdominal surgery and to identify its associated risk factors for LOS and outcome of treatment.

Methods

Study setting and surgical features

This study included data from the General Surgical Unit of the TTH, a referral healthcare centre serving northern Ghana with six operating rooms. At the TTH, surgical care is provided on a National Health Insurance Scheme (NHIS) and individuals who are not insured pay for the full cost of treatments. The TTH has inconsistent electricity and water supply, especially during the dry season, impacting the function and integrity of sterilization equipment.

Diagnosis of SSI is made according to clinical or radiological findings upon evaluation by a medical officer with at least two-year experience in medical practice and a radiographer, respectively. Specifically, at the TTH, SSI is diagnosed when there is purulent drainage from the incision or at least one of the following features: pain or tenderness; localized swelling; redness; heat; fever; the opening of the incision deliberately or spontaneously by dehiscence; abscesses within the wound. SSI is categorized as superficial, deep or organ–space. A superficial wound infection involves the skin and subcutaneous tissues of the incision. A deep infection involves infection of the deep tissues, such as the fascia and muscle layers. An organ–space infection involves any part of the anatomy other than the incision, which was opened or manipulated during the surgical procedure [6].

All operated patients received a perioperative empirical antibiotic covering, for 5–7 days, because all of the wounds were classified as contaminated or dirty at the time of surgery. Antibiotic was given initially via the intravenous route and then switched to oral when indicated, and commonly included combination therapy with the two drugs was used, third-generation cephalosporin (ceftriaxone) which was administered along with either metronidazole or ciprofloxacin and metronidazole. Anaesthetic service was provided by trained nurse anaesthetists.

Study population

All patients undergoing emergency abdominal surgery at the TTH between June 2010 and June 2015 were included in this study.

Data collection

Demographic and clinical data, including patient age and sex, type of procedure performed, wound class (dirty or contaminated), receipt of perioperative blood transfusion, ASA score, SSI, length of surgery, LOS and outcome of SSI treatment, were prospectively collected using a standardized paper form and then entered into an electronic spreadsheet.

Statistical analysis

All statistical analyses were performed using SPSS software (version 21.0; SPSS Inc., Chicago, IL, USA). Standard multiple regression was carried out to assess independent variables being entered into the equation simultaneously to determine how well this set of risk factors is able to predict SSI. Beta (β) values < 0.05 were considered significant.

Results

A total of 1011 patients underwent various emergency abdominal surgical procedures during the period of this study. The patients ranged in age from 1-year-old to

80-years-old (Fig. 1) and were predominantly male (Table 1). The most frequent reason for the abdominal surgery was a complicated hernia, followed by intestinal typhoid perforation, acute appendicitis, perforated peptic ulcer and blunt abdominal trauma. Surgeries for various other reasons included biliary and colon conditions. Haemoglobin level was abnormally low in approximately one-third of the operated patients (normal: 13.5–17.5 g/dL for men and 12.0–15.5 g/dL for women). Less than 10% of the patients received a blood transfusion, and the majority of the patients had ASA scores of I-IIE (i.e. predictive of less blood loss). While all wounds were classified as either dirty or contaminated, the former was two times more frequent.

Overall, SSI was clinically diagnosed in 116 (11.5%) of the patients. Patients with SSI had substantially longer LOS (four times) than the patients without SSI. Mortality among patients with SSI was twice as high as that for patients without SSI (Table 1).

As shown in Table 2, the coefficients of the *P* values for wound class (dirty or contaminated) and haemoglobin < 10 g/dL indicate that these two variables make a significant independent contribution to the prediction of SSI. In contrast, neither receipt of blood transfusion, patient sex, ASA score, possession of health insurance, a referral from other healthcare facilities nor patient age made a statistically significant contribution to SSI. Since

Fig. 1 Age range of patients ($n = 1011$)

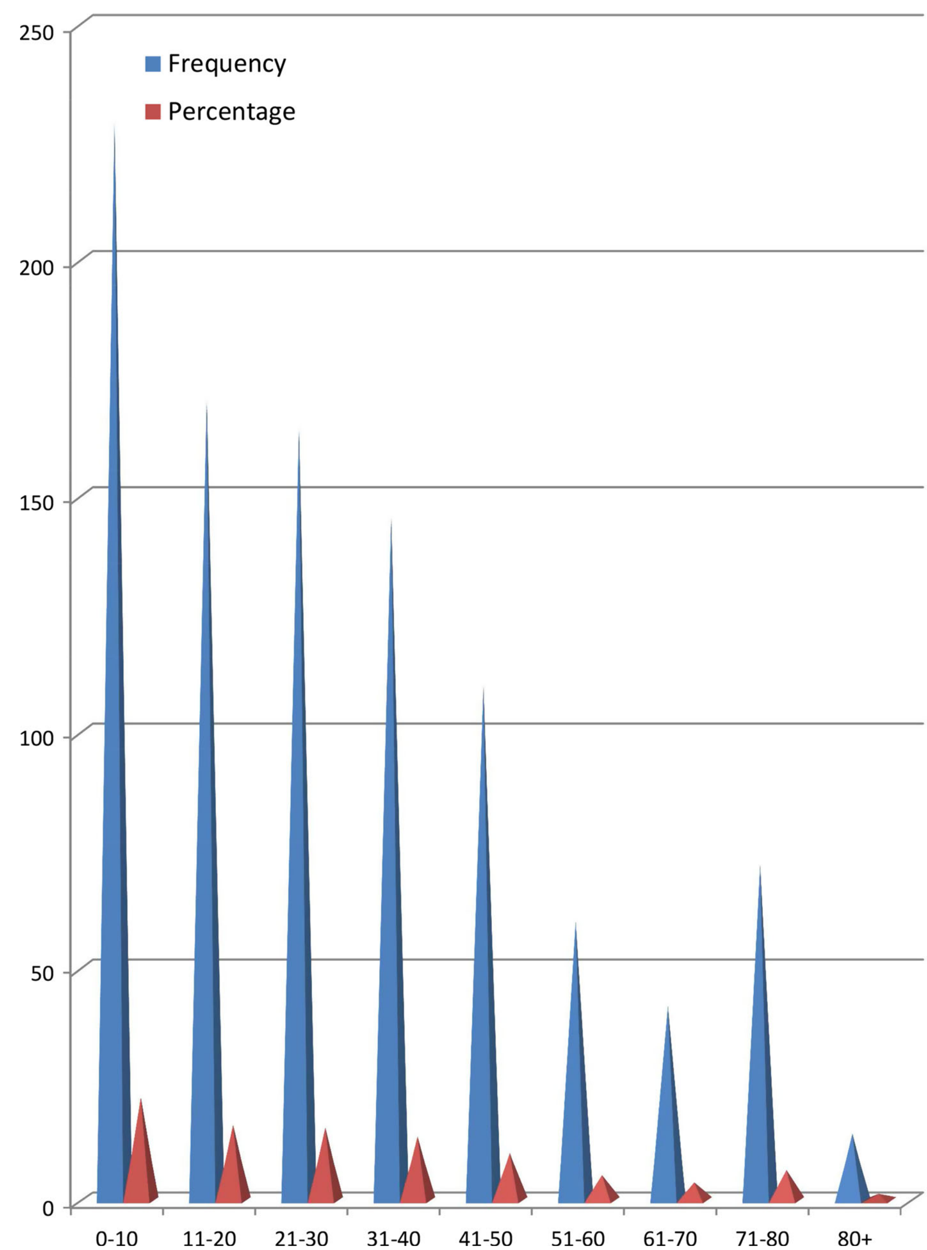

Table 1 Demographic and clinical information of patients

Characteristic	Frequency	Percentage
Sex		
Male	786	77.7
Female	225	22.3
Type of wound		
Contaminated	396	39.2
Dirty	615	60.8
Operation performed		
Complicated hernia	450	44.5
Typhoid perforation	166	16.4
Acute appendicitis	145	14.3
Perforated peptic ulcer disease	102	10.1
Colon surgery	46	4.5
Traumatic perforation of small bowel	32	3.2
Others	70	6.9
Haemoglobin in g/dL		
3–9	363	35.9
$\geq$ 10	648	64.1
American Society of Anesthesiologists score		
IE-IIE	744	73.6
> IIE	267	26.4
Perioperative blood transfusion	81	8.0
Surgical site infection		
Superficial surgical site infection	55	5.4
Deep surgical site infection/Organ–space	61	6.0
Outcome		
Satisfactory	966	95.5
Died	45	4.5

the β values indicated the relative influence of the entered variable(s), the variable(s) with the highest β values would have the greatest influence on overall SSI. In this case, sex and ASA score showed the two highest β values, and receipt of blood transfusion and possession of health insurance showed the two lowest. Thus, there was a positive correlation between the variables, with sex being the most distinctive contributor to the overall SSI and with the least influence being made by possession of health insurance, suggesting that sex and ASA score are the best predictors of SSI.

The Pearson correlation coefficient value for SSI and LOS (Table 3) suggests that LOS is associated with overall SSI and vice versa. The matrix of significance levels in terms of one-tailed tests shows that LOS (predictor) did not correlate significantly ($P > 0.01$) with the dependant variable of overall SSI at the 0.05 level. The correlation of 0.997 provided no evidence of a strong, positive correlation between LOS and overall SSI, with high levels of LOS being associated with high levels of overall SSI and vice versa. Squaring of the correlation value ($r = 0.997$) yielded the finding of 99.4% shared variance. This suggests that LOS helps to explain 99% of the variance in the data on SSI.

Similarly, the Pearson correlation coefficient of SSI and outcome of surgery indicate that outcome of surgery is associated with overall SSI and vice versa (Table 4).

Discussion

SSI is considered the most common cause of nosocomial infections, accounting for 25–40% of all hospital infections [7, 8]. Furthermore, it is associated with high morbidity and mortality rates, as well as substantial medical costs [9–12]. Mortality, morbidity, increased LOS and excess direct/indirect costs have all been directly attributed to SSI [13]. Post-operative mortality has been used to assess the quality

Table 2 Risk factors of SSI when the dependent variable is the SSI (SSI dummy)

Model	Unstandardized coefficients		Standardized coefficients	*t*	*P* value	95% Confidence interval for β	
	β	Std. error	β			Lower bound	Upper bound
1							
(Constant)	0.180	0.103		1.747	0.081	− 0.022	0.382
NHIS	− 0.001	0.029	− 0.001	− 0.041	0.967	− 0.058	0.055
Sex	0.038	0.025	0.050	1.557	0.120	− 0.010	0.087
Age	0.005	0.005	0.034	1.055	0.292	− 0.004	0.014
Referral	0.027	0.023	0.037	1.173	0.241	− 0.018	0.073
ASA	− 0.003	0.002	− 0.048	− 1.508	0.132	− 0.007	0.001
Wound class	− 0.130	0.022	− 0.199	− 5.922	0.000	− 0.173	− 0.087
Haemoglobin in g/dL	0.029	0.013	0.069	2.151	0.032	0.003	0.055
Blood transfusion	− 0.009	0.037	− 0.008	− .246	0.805	− 0.081	0.063

ASA American Society of Anesthesiologists, *NHIS* National health insurance scheme, *SSI* surgical site infection

Table 3 Correlation of SSI and length of hospital stay

Correlation			
		SSI dummy	LOS
SSI dummy	Pearson correlation	1	0.000
	Sig. (two-tailed)		0.997
	n	1011	1011
LOS	Pearson correlation	0.000	1
	Sig. (two-tailed)	0.997	
	n	1011	1011

LOS length of hospital stay, *SSI* surgical site infection

Table 4 Correlation of SSI with surgical treatment outcome

Correlation			
		SSI	Outcome
SSI dummy	Pearson correlation	1	0.088**
	Sig. (two-tailed)		0.005
	n	1011	1011
Outcome	Pearson correlation	0.088**	1
	Sig. (two-tailed)	0.005	
	n	1011	1011

** Correlation is significant at the 0.01 level (two-tailed)

SSI surgical site infection

of surgical care, in general, but it has not proven to be a completely sensitive indicator as it occurs in 1–3% of patients [14, 15].

Several systematic approaches have been proposed to assess the quality of surgical care in the high-income countries (HICs); however, these approaches are complex and are mostly not suitable for use in the healthcare/surgical settings of LMICs, where the rate of SSI is generally much higher (compared to the HICs). Therefore, SSI has been proposed as a good alternative for assessing the quality of surgical care in LMICs [16].

In the current study, we used SSI to measure the quality of surgical care and to identify associated risk factors with the aim of improving quality of surgical services in our LMIC healthcare setting (the TTH). The overall in-hospital SSI rate of TTH for the study period was 11.5%, and it is likely that this rate would have been much higher if a 30-daypost-operative follow-up of SSI had been used. Similarly, high rates of SSI have been reported by Jido et al. [17] in Nigeria, Jjuko et al. [18] in South Africa and Patel et al. [19] in India; these are in comparison with rates reported from such HICs as the USA (2.8%) and for countries in Europe (2–5%) [13].

For the TTH, in particular, the high SSI rate compare to HICs is almost certainly influenced by the routine disruptions in water and electric supply. For example, inconsistent water and electricity supply translates to inadequate capacity for equipment sterilization [20–22] and improper hygiene of the healthcare workers and patients, as well as leads to patient malnutrition and late presentation for surgical care [22].

As in many LMICs, post-operative follow-up of patients out to 30 days after hospital discharge proved extremely difficult in our study. Besides the general lack of infrastructure to support such systematic post-hospitalization communication, many other challenges exist, such as the long distances travelled by a large number of patients who seek treatment at our facility, financial difficulties and lack of a reliable and convenient transportation network, just to mention a few. We therefore limited our study to the in-hospital diagnosis of SSI, which will certainly lead to an underestimation of the real burden of SSI in our hospital. The LOS of patients with SSI in our study is comparable to that reported by Chu et al. [10] (7–10 days) in patients with SSI but distinctly higher than that reported by Berrios et al. [23] in the same time post-surgery in patients with SSI. Moreover, these reports cited in-hospital mortality rates of 2 and 11%, respectively, among the patients with SSI. Thus, the mortality rate found in this study for the TTH compares favourably.

In hospitals such as the TTH, where resources are limited, simply having patients stay for an additional 2 weeks to address the development of an SSI presents a remarkable burden on the already constrained healthcare system. Understanding the features underlying SSIs in order to reduce their incidence will reduce LOS and morbidity, allow patients to return to their families and workplaces earlier, allow other patients to be treated and also reduce costs for the patient. Besides the extended LOS, some of the patients who developed organ–space SSI also had to be re-operated and/or admitted to the intensive care unit of the hospital, adding further costs to the patients' bills.

The results of this study identified the risk factors of SSI at TTH as sex, wound class (dirty or contaminated), preoperative haemoglobin and perioperative blood transfusion. These factors are consistent with findings from studies of other surgical institutes with various populations and procedural features, including those in HICs [24–26]. Numerous bacteria—the sources of the SSI—thrive in contaminated and dirty wounds. Unfortunately, bacteria culturing and sensitivity analysis/susceptibility testing were not performed in this study for the same reasons involving infrastructure that makes LMIC healthcare facilities, like TTH, more likely to have SSIs, namely the erratic electricity and water supply and the absence of sterile specimen containers or functional storage and laboratory testing equipment.

The association of perioperative anaemia and blood transfusion with SSI remains a topic of controversy in the literature. Walz et al. [27] validated perioperative blood transfusion as an independent risk factor for the development of SSI, but another study achieved contradictory results [28]. Our study, along with another [29], suggests that preoperative low haemoglobin levels contribute significantly to the development of SSI while the contribution of perioperative blood transfusion is insignificant. We identified ASA as an independent risk factor for SSI, which agrees with the findings reported by Chang et al. [30] and Tran et al. [31]. The wound class (dirty or contaminated) also showed a significant impact on the rate of SSI in our study. Male sex is shown to be at risk of SSI because they tend to present late to the hospital by Ohene-Yeboah et al. [32].

In recent years, negative pressure wound therapy (e.g. wound VAC.) has been used successfully to reduce SSI in contaminated or dirty wounds [33, 34]. However, this is system is not available in our facility. We performed closure of the fascia and muscle en masse. The skin is approximated with interrupted sutures, at 4 cm apart, to allow for drainage. The reason for the adapted suture closure of the skin is to prevent wide gapping of the wound and to enhance secondary closure if infection occurs.

There are some limitations to our study design that must be considered when interpreting our findings. Comorbidities such as human immunodeficiency virus infection, diabetes mellitus and intraoperative factors such as duration of the surgery and amount of blood lost were not considered in this study and may have influenced the occurrence or progression of SSI in our patients.

Conclusion

Patient age and sex, ASA score, perioperative low haemoglobin level (< 10 g/dL) and wound class (dirty or contaminated) predispose to SSI in patients undergoing abdominal surgery at TTH, a representative LMIC healthcare institute. SSI is associated with increased LOS and outcome of treatment. Further, research should take into consideration the influence of inconsistent water supply and erratic power supply, as well as the duration of surgery and presence of comorbidities.

Author's contribution TS designed the research, was responsible for gaining approval by the institutional review board (IRB), and oversaw the manuscript preparation and finalization; YE wrote the methodology and results in sections of the manuscript; KM composed the discussion and conclusion sections of the manuscript; ATTK collected the data and wrote the introduction section of the manuscript; all authors read and approved the final manuscript.

Compliance with ethical standards

Institutional review board statement IRB approval was granted by the Tamale Teaching Hospital Ethical Committee (No. TTHERC 1454).

Conflict of interest The authors declare no conflicts of interest related to the study or its publication.

Informed consent Informed consent was not required for this study according to the IRB approval by the Ethical Committee, based on the standard practice of the Tamale Teaching Hospital.

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