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Rate and risk factors of surgical site infection following abdominal surgery; a prospective study

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ABSTRACT

Aims: Surgical site infection (SSI) remains a significant cause of morbidity and financial burden on patients. This study aimed to describe the incidence and risk factors associated with developing SSI in adult patients after abdominal surgery.

Methods: In this 6-month prospective observational study, adult patients undergoing abdominal surgery at the gastrointestinal surgery unit of our tertiary referral center were included. Excluded from the study were patients lost to follow-up; additionally, this study does not include urological, gynecological, vascular, plastic, or transplant surgeries. Patients were followed up for 30 days, data collection was done using a standardized data collection form, and SSI was diagnosed according to the Centers for Disease Control and Prevention definition. Univariate and multivariate analyses were performed to identify risk factors for SSI.

Results: The study included a total of 212 patients. The incidence of SSI was 32.5%. Emergency operations, male gender, and high body-mass index were identified as independent predictors of SSI. The most commonly isolated organisms in analyzed cultures were *Klebsiella* spp.

Conclusion: A high rate of SSI following abdominal surgery was observed. Periodic audits to assess compliance with established standard infection control measures, review of prophylactic antibiotic guidelines, as well as addressing modifiable risk factors have the prospect of reducing SSI.

Keywords: Surgical site infection, abdominal surgery, risk factors, antibiotic resistance

INTRODUCTION

Surgical site infection (SSI) is a common complication following surgery and one of the most common preventable healthcare-associated infections. SSI occurs in 0.6% to 9.5% of all surgical procedures, according to the type of surgery.[1] According to a multicenter 18-month prospective study in 2016, the incidence of SSI in Egypt is 12%.[2] Incidences as high as 15%-25% have been reported following abdominal surgeries and up to 39.8% following gastrointestinal surgeries depending on the contamination level of the surgical wound.[3,4]

According to the Center for Disease Control and Prevention's National Health Safety Network (CDC/PNHSN) of the United States, an infection in the area where surgery took place, occurring within 30 days after surgery (or up to 1 year when an implant is utilized) is considered SSI. This is further classified into superficial incisional (infections involving only the skin and subcutaneous tissue), deep incisional (infections involving muscle and fascial layers), and organ/space SSI (Infection involving any part of the anatomy deep to muscle/fascia layers).[5-7]

Compared to uninfected patients, patients who develop SSI have longer postoperative hospital stay in the wards and intensive care units (ICU), and increased requirements for further interventions including additional medications, investigations, and hospital readmission. An increased need for further surgical interventions ranging from imaging-guided procedures to outright reoperation is also seen in this group of patients. Prolonged hospitalization and the need for further therapy, as a consequence, incur additional costs. All these, in addition to intangible costs of pain and suffering, affect patients' quality of life, increasing postoperative morbidity and risk of mortality in SSI patients.[8,9]

Many factors that put surgical patients at risk of developing SSI have been reported. The CDC's National Nosocomial Infections Surveillance System (NNIS) risk index is a model of SSI risk prediction that has been relatively accurate in abdominal surgeries. The components of the NNIS risk index include the ASA score, surgical wound class, and duration of operation.[10,11] Other recognized risk factors include high body-

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mass index (BMI), advancing patient age, malignancy, diabetes mellitus, previous radiation or chemotherapy, smoking, and preoperative hair removal a day before surgery.[12,13]

The main goal of our study was to describe the incidence and identify the risk factors associated with developing SSI in adult patients undergoing abdominal surgery. The secondary goals were to identify organisms causing SSI and their antibiotic resistance pattern; assess postoperative morbidity using the Clavien-Dindo classification; and the influence of SSI on length of postoperative hospital stay.

METHODS

Ethics

Ethical approval was obtained from the Alexandria University Ethics Committee (Date: 15.12.2022, Decision No: 0107502). Informed consent was obtained from all participants in the study. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Patients

This six-month prospective observational study was conducted at the Gastrointestinal Surgery Unit of our Tertiary Referral Center and included patients aged ≥18 undergoing abdominal surgery between November 1st, 2022, and April 30, 2023. Patients whose wounds were not primarily closed, as well as those lost to follow up, were excluded. This study does not include abdominal procedures for urological, vascular, plastic, gynecological or transplant surgeries as those procedures are not part of the spectrum carried out at our surgery unit.

Study Technique

All patients were admitted through the outpatient clinic or emergency department. Preoperative assessment included thorough history taking, clinical examination, and investigations. All patients received pre-operative prophylactic antibiotics according to the Alexandria Main University Hospital Surgical prophylaxis guidelines (2 g cefoxitin/ceftriaxone for non-gastrointestinal surgeries; IV 500 mg metronidazole added for gastrointestinal surgeries, pancreatic and emergency hernia surgeries. IV 400 mg ciprofloxacin+metronidazole used for biliary surgeries) at induction of anesthesia. Skin preparation was done with povidone-iodine (Betadine®) before skin incision. Patients were monitored for signs of SSI in the ward and followed up in the outpatient clinic after discharge for 30 days after surgery. SSI was diagnosed according to the CDC/PNHSN definition. Patients who developed SSI had wound discharge taken from infected wounds and sent for culture and sensitivity and findings were recorded.

Data Collection

Data collection was done using a standardized data collection form.

Preoperative data included demographic data, past medical and surgical history, drug/therapy history (steroid, chemotherapy, radiotherapy), and smoking history. BMI (kg/m^2) and ASA Classification, preoperative hemoglobin, blood urea and serum creatinine, and serum albumin.

Intraoperative data included urgency of operation (elective or emergency), the surgeon (consultant or trainee), use of general anesthesia (GA), approach (open or laparoscopic), duration of the procedure, blood transfusion, surgical wound classification and gastrointestinal (GIT) surgery (yes or no); defined as any operation involving transmural breach (repair of perforation, transection, resection, re-anastomosis, creation or reversal of stoma) in any part of the GIT from the lower esophagus to the rectum including extra-hepatic biliary tract.

Postoperative data postoperative length of hospital stay, ICU admission, postoperative morbidity and mortality assessed by Clavien-Dindo classification.

Statistical Analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using numbers and percentages. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, and median. The significance of the obtained results was judged at the 5% level. An initial comparison of all independent variables between the groups of patients with and without SSI was done. The dependent variable was SSI. Chi-square test (for categorical variables), Fisher's exact or Monte Carlo correction (Correction for Chi-square when more than 20% of the cells have an expected count of less than 5), student t-test (for normally distributed quantitative variables) and Mann-Whitney test (for abnormally distributed quantitative variables) were the tests used. For the variables that showed statistically significant differences (p-value <0.05) between both groups, univariate and multivariate logistic regression analyses were done to identify risk factors for developing SSI.

RESULTS

The study included 212 patients; 117 (55.2%) were male, and 95 (44.8%) were female. The mean age of the study population was 45±16 years. Six patients died before the end of 30 days of follow-up.

Fifty-nine (27.8%) patients were smokers, 35 (16.5%) were diabetic, 35 had cardiovascular (CVS) disease, 32 had malignant diseases, and 25 (11.8%) had a history of previous laparotomy.

One hundred and forty-one (66.5%) patients underwent elective surgery. Sixty-two cases (29.2%) were performed laparoscopically. GIT surgeries made up 65.6% (n=139) of cases. The mean operative time was 136.5 minutes. The majority of the procedures (110, 51.9%) were classified as clean-contaminated, while 62 (29.2%) were classified as either contaminated or dirty procedures.

The overall rate of SSI was 32.5% (69/212). Forty (58%) of the patients with SSI had superficial infections, 24 (34.8%) had deep infections, and 5 (7.2%) had organ/space SSI (Table 1). Incidence was 49.2% and 24.1% in emergency and elective surgery, respectively. The rate of SSI following laparoscopic surgeries was 14.5% and 40% following open surgeries. The observed rates of SSI in the different wound classes were recorded (Table 2); 12.5% in clean wounds, and 75% dirty wounds. The incidence of SSI in GIT surgeries was 36.7%. Table 3 shows the incidence per surgical procedure included in this study.

Table 1. Proportion of SSI by depth of tissue involved

Class	No (total SSI=69)	Percentage
Superficial incisional	40	58%
Deep incisional	24	34.8%
Organ/space	5	7.2%

SSI: Surgical site infection

Table 2. Surgical site infection rate according to wound class *p<0.001 highly significant ($\chi 2$=24.314)

Wound class	Total (n=212)	SSI (n=69)	Percentage of SSI
Clean	40	5	12.5%
Clean-contaminated	110	30	27.2%
Contaminated	50	25	50%
Dirty	12	9	75%

*: Statistically significant at p≤0.05. χ : Chi square test. SSI: Surgical site infection

Table 3. Surgical site infections according to surgical procedure

Procedure	No of patients (n=212)	No of SSI (n=69)	Percentage (%)
Laparoscopic cholecystectomy	37	5	13.5
Colon and rectal surgery	30	15	50
Incisional hernia repair	16	5	31.3
Other hernia repair	30	5	16.7
Exploratory laparotomy	33	17	51.5
Appendectomy	19	6	31.6
Pancreatic, hepatic, and biliary surgery	21	10	47.6
Gastrectomy, gastrojejunostomy, bariatric	14	3	21.4
Other	12	3	25

SSI: Surgical site infection

In the initial comparison of risk variables between patient groups with and without SSI, diabetes mellitus, smoking, use of GA, and 30-day postoperative mortality showed no statistically significant difference between the two groups. (Table 4, 5).

Multivariate analyses identified emergency operations [OR=4.640, 95% confidence interval (CI)=1.061-20.282], male gender (OR=2.678, 95% CI=1.152-6.222), and higher BMI (OR=1.133, 95% CI=1.059-1.21) as independent predictors of SSI.

Other risk factors associated with SSI identified from univariate analyses included lower serum albumin, ASA class of >II, previous laparotomy, intraoperative blood transfusion, contaminated/dirty wound class, longer duration of operation, postoperative ICU admission, >class II of the Clavien-Dindo classification of postoperative morbidity, and longer postoperative hospital stay (Table 6). Serum albumin and HCV-Ab were excluded from multivariate analysis as they were not tested in all patients.

From a total of 65 samples collected, we obtained 74 isolates. Gram-negative bacilli accounted for 82% (n=61) of the cultured organisms and 95% of those organisms exhibited the following pattern of antibiotic resistance: multi drug resistant (MDR) (resistant to ≥1 agent in ≥ 3 antimicrobial categories)=31.1% (19/61); extended drug resistant (XDR) (resistant to ≥ 1 agent in all but 2 or fewer antimicrobial categories)=60.7%; Pan drug resistant (PDR) (resistant to all agents in all antimicrobial categories)=3.3% (Table 7). The majority of the samples cultured a single organism and the most commonly isolated organism was *Klebsiella* spp. (34 isolates, 45.9%) followed by *E. coli* (12 isolates, 16.2%) and *Acinetobacter baumannii* (9 isolates, 12.1%). Six cultures (8.1%) yielded no growth (Figure).

Table 4. Comparison of demographic and preoperative data of patients with and without SSI

Variable	Total (n=212) No.‡	%‡	No SSI (n=143) No.‡	%‡	SSI (n=69) No.‡	%‡	Test of sig.	p-value
Gender								
Male	117	55.2	71	49.7	46	66.7	χ^2=5.449	0.020*
Female	95	44.8	72	50.3	23	33.3		
Age (years) mean±SD	45.1±16.0		44.5±16.0		46.2±16.2		t=0.716	0.475
Diabetic	35	16.5	19	13.3	16	23.2	χ^2=3.311	0.069
Cardiovascular disease	35	16.5	24	16.8	11	15.9	χ^2=0.024	0.877
Cancer	32	15.1	17	11.9	15	21.7	χ^2=3.524	0.060
Liver disease	11	5.2	4	2.8	7	10.1	χ^2=5.108	FEp=0.042*
Previous laparotomy	25	11.8	12	8.4	13	18.8	χ^2=4.885	0.027*
Smoking	59	27.8	37	25.9	22	31.9	χ^2=0.837	0.360
Steroid	2	0.9	1	0.7	1	1.4	χ^2=0.280	FEp=0.546
Chemotherapy	9	4.2	4	2.8	5	7.2	χ^2=2.266	FEp=0.155
ASA class								
I	71	33.5	63	44.1	8	11.6		
II	74	34.9	50	35.0	24	34.8	χ^2=30.624	<0.001*
III	38	17.9	16	11.2	22	31.9		
IV	29	13.7	14	9.8	15	21.7		
≠HBsAg								
Negative	156	73.6	108	75.5	48	69.6	χ^2=1.407	MCp=0.546
Positive	4	1.9	2	1.4	2	2.9		
≠HCV-Ab								
Negative	154	72.6	109	76.2	45	65.2	χ^2=7.483	MCp=0.021*
Positive	6	2.8	1	0.7	5	7.2		
BMI (kg/m²) median (IQR)	28.0 (24.4-31.0)		28.0 (23.8-30.0)		29.0 (28.0-32.0)		U=3251.0	<0.001*
Pre-op stay (days) median (IQR)	5.0 (1.0-12.0)		6.0 (2.0-12.0)		2.0 (1.0-9.0)		U=3816.50	0.008*
Hemoglobin (g/dl) mean±SD	12.8±2.4		12.9±3.2		12.8±1.9		t=0.202	0.840
≠Albumin (g/dl) median (IQR)	4.2 (3.7-4.5)		4.30 (4.0-4.6)		4.0 (3.40-4.30)		U=1456.5	<0.001*
Urea (mg/dl) median (IQR)	28.0 (24.0-39.0)		28.0 (24.0-36.0)		28.0 (24.0-43.0)		U=4697.0	0.571
Creatinine (mg/dl) median (IQR)	0.8 (0.6-0.9)		0.70 (0.6-0.9)		0.80 (0.6-1.0)		U=4096.0	0.043*

SSI: Surgical site infection, SD: Standard deviation, ASA: American Society of Anesthesiologists, HBsAg: Hepatitis B surface antigen, HCV-Ab: Hepatitis C virus antibody, BMI: Body-mass index, IQR: Interquartile range, c^2: Chi-square test, FE: Fisher exact, U: Mann-Whitney test, t: Student t-test, *: Statistically significant at p≤0.05, ≠: n<212, ‡: unless specified

DISCUSSION

The overall incidence of SSI in our study was 32.5%. Our rate is higher than many other reported incidences in other lower-middle-income countries in Africa and Asia, ranging from 13-30.7%.[14-18] Interestingly, Deyem et al.[19] findings in Congo are similar to ours at 32.6%. In another study in Egypt by Ghanem et al.[20] a rate of 38.6% was observed. The high incidence observed in our study can partly be attributed to hospital environment-related factors, the complexity of procedures, and the absence of an instituted active surveillance system. In addition, this study was conducted in a low- to mid-income country with surgical resource constraints. Our

Table 5. Comparison of operative and postoperative data of patients with and without SSI

Variable	Total (n=212) No.‡	Total (n=212) %‡	No SSI (n=143) No.‡	No SSI (n=143) %‡	SSI (n=69) No.‡	SSI (n=69) %‡	Test of sig.	p-value
Surgeon								
Consultant	71	33.5	49	34.3	22	31.9	χ^2=0.119	0.731
Trainee	141	66.5	94	65.7	47	68.1		
Operative type								
Elective	141	66.5	107	74.8	34	49.3	χ^2=13.640	FEp<0.001*
Emergency	71	33.5	36	25.2	35	50.7		
Approach								
Open	150	70.8	90	62.9	60	87.0	χ^2=12.977	<0.001*
Laparoscopic	62	29.2	53	37.1	9	13.0		
Gastrointestinal surgery								
Yes	139	65.6	88	61.5	51	73.9	χ^2=3.157	0.076
No	73	34.4	55	38.5	18	26.1		
General anesthesia	189	89.2	124	86.7	65	94.2	χ^2=2.699	0.100
Surgical wound class								
Class I	40	18.9	35	24.5	5	7.2	χ^2=24.314	<0.001*
Class II	110	51.9	81	56.6	30	43.5		
Class III	50	23.6	25	17.5	25	36.2		
Class IV	12	5.7	3	2.1	9	13.0		
Blood transfusion	51	24.1	25	17.5	26	37.7	χ^2=10.394	0.001*
Drain	182	85.8	118	82.5	64	92.8	χ^2=4.014	0.045*
Duration of surgery (min.), median (IQR)	136.5 (104-200)		130.0 (99-192)		183.0 (130-215)		U=3196.500	<0.001*
Skin closure								
Suture	170	80.6	118	83.1	52	75.4	χ^2=1.775	0.183
Staple	41	19.4	24	16.9	17	24.6		
Intensive care unit admission	47	22.2	23	16.1	24	34.8	χ^2=9.431	0.002*
Mortality	6	2.8	2	1.4	4	5.8	χ^2=3.274	FEp=0.089
Clavien Dindo class								
≤II	165	77.8	121	84.6	44	63.8	χ^2=11.723	0.001*
III-V	47	22.2	22	15.4	25	36.2		
Post-operative stay (d), median (IQR)	4.0 (2.0-6.0)		3.0 (1.0-5.50)		6.0 (4.0-10.0)		U=2661.50	<0.001*

SSI: Surgical site infection, Min: Minute, IQR: Inter quartile range, c^2: Chi-square test, FE: Fisher exact, U: Mann Whitney test, ‡: unless specified, *: Statistically significant at p≤0.05

Table 7. Pattern of antibiotic resistance among gram-negative isolates

	Total isolates	MDR No. (%)	XDR No. (%)	PDR No. (%)
Klebsiella spp.	34	6 (17.6)	26 (76.5)	2 (5.9)
Escherichia coli	12	6 (50.0)	4 (33.3)	0 (0.0)
Acinetobacter baumannii	9	3 (33.3)	6 (66.7)	0 (0.0)
Proteus mirabilis	3	2 (66.7)	1 (33.3)	0 (0.0)
Pseudomonas aeruginosa	3	2 (66.7)	0 (0.0)	0 (0.0)
Total	61	19 (31.1)	37 (60.7)	2 (3.3)

MDR: Multi drug resistant (resistant to ≥1 agent in ≥3 antimicrobial categories), XDR: Extended drug resistant (resistant to ≥1 agent in all but 2 or fewer antimicrobial categories), PDR: Pan drug resistant (resistant to all agents in all antimicrobial categories)

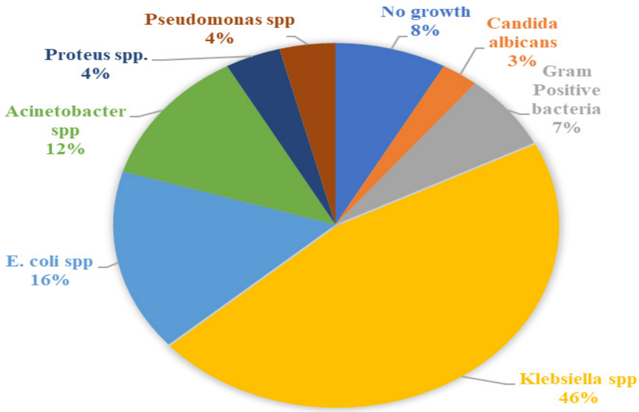

Figure. Culture report

findings highlight insufficient awareness of hospital-acquired infections alongside subpar infection control measures in our center.

The authors also observed that, consistent with existing literature, the incidence of SSI rose progressively from clean to dirty wounds.[3,15,21]

The independent risk factors identified in the multivariate analysis in our study were male gender, emergency surgery, and high BMI (>28 kg/m^2). Male patients were almost three

Table 6. Univariate and multivariate logistic regression analyses to detect the most independent risk factors

Variable	Univariate p-value	Univariate OR (LL-UL 95% CI)	Multivariate p-value	Multivariate OR (LL-UL 95% CI)
Male gender	0.021*	2.028 (1.115 - 3.689)	0.022*	2.678 (1.152-6.222)
Liver disease	0.034*	3.923 (1.108-13.893)	0.134	4.628 (0.623-34.366)
Previous laparotomy	0.031*	2.534 (1.089-5.898)	0.335	1.748 (0.561-5.443)
≠Albumin (mg/dl)	<0.001*	0.267 (0.138-0.519)		
Creatinine	0.018*	1.937 (1.119 - 3.355)	0.465	1.110 (0.838-1.471)
≠HCV-Ab positive	0.025*	12.111 (1.376 - 106.598)		
Body-mass index (kg/m^2)	0.003*	1.078 (1.027 - 1.132)	<0.001*	1.133 (1.059-1.213)
ASA score (III & IV) vs (I & II)	<0.001*	4.355 (2.340 - 8.106)	0.466	1.419 (0.554-3.6631)
Pre-operative stay (days)	0.302	0.976 (0.932-1.022)		
Urgency of operation (emergency)	<0.001*	3.060 (1.672 - 5.600)	0.041*	4.640 (1.061-20.282)
Approach (open)	0.001*	3.926 (1.802 - 8.551)	0.155	2.568 (0.701-9.404)
Blood transfusion	0.002*	2.854 (1.489 - 5.470)	0.908	0.940 (0.331-2.672)
Drain	0.052	2.712 (0.990 - 7.425)		
Duration of surgery (min.)	<0.001*	1.007 (1.003-1.011)	0.486	1.002 (0.996-1.008)
Surgical wound class (III & IV vs I & II)	<0.001*	3.990 (2.131 - 7.470)	0.117	2.120 (0.828-5.425)
Intensive care unit admission	0.003*	2.783 (1.429 - 5.420)	0.683	0.781 (0.238-2.559)
Clavien Dindo (≥III)	0.001*	3.125 (1.601-6.100)	0.809	1.169 (0.329-4.146)
Post-operative stay (days)	<0.001*	1.263 (1.155-1.381)	0.059	1.141 (0.995-1.307)

OR: Odds ratio, CI: Confidence interval, LL: Lower limit, UL: Upper limit, HCV-Ab: Hepatitis C virus antibody, ASA: American Society of Anesthesiologists, Min: Minute, *: Statistically significant at p≤0.05, ≠: Excluded from multivariate because n<212 times more likely to develop SSI compared to females. Similar findings have been reported in the literature.[3,14,22] The specific reason for male susceptibility was not evaluated in this study. The odds of developing SSI following emergency surgery were 4.6 times higher than those of elective surgery. This compares favorably with similar studies that identify emergency operation as an independent risk factor in multivariate analyses.[3,23] Patients with higher BMI were at an increased risk of developing SSI, a trend consistently supported by existing medical research.[24-26]

Univariate logistic regression analysis identified some other known risk factors assessed in our study that might have played a role in the high incidence observed in our study. Factors correlated with higher risk of SSI in univariable analysis were: history of previous laparotomy, lower serum albumin (mean of 3.8 vs 4.2 in SSI Vs no SSI, p<0.001), higher serum creatinine, ASA class of more than II, intraoperative blood transfusion, contaminated/dirty wound class, duration of operation >130 minutes, and postoperative ICU admission. The median postoperative length of the hospital stay was also longer in patients with SSI compared to patients without SSI (6d vs 3d, p<0.001). These observations are akin to previously reported findings in the literature.[26-31] The odds of developing SSI in patients with liver disease were 3.9, and patients who tested positive for HCV Ab also had a significantly higher risk. The association of liver disease and hepatitis C-positive status with SSI is not novel.[32-34]

The patients' age and presence of cardiovascular disease were not risk factors for developing SSI in our study. A similar outcome has been reported previously in the literature.[23] Although these findings are contrary to those previously reported in Alexandria, Egypt.[35] Smoking status was not a predictor of SSI in our study and compares favorably with a large study (n=1.062) assessing risk factors of SSI.[36]

The proportion of diabetic patients was higher in the SSI group (16/69; 23.2%) than those without SSI (19/143; 13.3%), the difference was, however, not statistically significant (p-value=0.069). This compares favorably with findings reported by Hafez et al.[36] in Egypt and compatible with findings elsewhere by Ott et al.,[37] Adejumo et al.,[38] Cheuk et al.[39] and Watanabe et al.[23] The authors observed that this index study and the above-listed studies that reported similar findings about diabetes and SSI identified other factors like high BMI, contaminated wound, and prolonged procedural time on logistic regression analysis. Suggesting that these other factors are the true drivers of SSI, eliminating diabetes as an independent risk variable, contrary to common findings in established literature. The presence of malignant disease did not increase the risk of SSI in our study.

The use of GA and placement of drains were not identified as risk factors for SSI in our study, and a similar outcome has been reported.[35] No difference was demonstrated in the rate of SSI in surgeries performed by consultants versus trainees, probably because consultants performed more complex procedures with longer procedural time, which increased the odds of SSI in our univariate analysis.

The rate of mortality was higher in the patient with SSI compared to those without SSI (5.8% vs 1.4%) but it was not statistically significant (p=0.089).

Gram-negative bacilli were the most commonly isolated organisms. The most implicated organism was *Klebsiella* spp. (45.9%) followed by *E. coli* (16.2%). Similar findings were reported by Abduo et al.[2] and Baro et al.[14] In a similar study by Alkaaki et al.,[3] *E. coli* (52%) was the predominant isolate followed by gram-positive bacteria (38%). Some studies have, however, revealed a predominance of gram-positive bacteria like *Staphylococcus aureus,* and *Enterococcus.*[40,41] Ninety-five percent of the cultured gram-negative bacilli in our study exhibited MDR/XDR/PDR. MDR organisms resist standard prophylactic antibiotics, they lead to higher rates of wound complications like SSIs. Consequently, these infections are associated with prolonged hospital stays and expensive specialized therapies.[42,43] We also found that only 19% of cultured organisms were sensitive to the prophylactic antibiotics used. These findings challenge the appropriateness of the current antibiotic prophylaxis protocol of our institution and call for urgent revision of the current guidelines.

Limitations

This is a single-center study that reflects a specific culture, population, and care protocol that may differ from practices elsewhere. While the standard surveillance time for SSI is 30 days as applied in our study, the optimal follow-up time for implant-based surgeries like hernioplasty is 90 days to a year, hence, the 30-days follow up represents another limitation of this study. The use of logistic regression analysis was to control for confounding factors to improve the validity of this observational study, however, some variables like the serum albumin level, were not analyzed in the multivariate regression model, as it was not done for all patients. The authors also wish to point out that the case-mix heterogeneity ranging from clean to contaminated/dirty procedures in the index study might skew and inflate the overall incidence of SSI.

CONCLUSION

A high rate (32.5%) of SSI following abdominal surgery was detected in our study. Fifty-eight percent of SSI cases were superficial incisional infections with no serious consequences. Male gender, emergency surgery, and high BMI were identified as independent risk factors for developing SSI following abdominal surgery. A number of other factors increasing susceptibility to SSI were also identified in the univariate analyses, including the components of NNIS risk index. M/XDR gram-negative bacilli were the most common isolates in the analyzed cultures. The most commonly isolated organism was *Klebsiella* spp. Ensuring the implementation of well-structured policies of infection control by periodic auditing; review of prophylactic antibiotic guidelines, as well as addressing modifiable risk factors have the prospect of reducing SSI.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Alexandria University Ethics Committee (Date: 15.12.2022, Decision No: 0107502).

Informed Consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. Participants were fully informed about the study's aims, procedures, potential risks and benefits, and their rights-including the right to withdraw at any time without consequence. All participants voluntarily signed a written informed consent form.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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Author Contributions

Concept: MRE; Design: HIA; Control: MM; Resources: AAG, MRE; Materials: AAG; Data Collection and/or Processing: HIA, MM; Analysis and/or Interpretation: MM; Literature Review: HIA; Writing the Article: HIA; Critical Review: MRE, AAG.

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