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Original Article

Risk factors of surgical site infection in elective laparotomy in a tertiary care center: an observational study

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Abstract: Introduction: Surgical site infections (SSI) encompass 20-25% of all hospital-acquired infections with their prevalence ranging from 2.5 to 41.9% across the world. Prevalence and risk factors of SSI vary greatly between countries and between healthcare institutions within a country. There is limited data on the pattern and risk factors of SSI in the Indian healthcare scenario. This study is an attempt to identify risk factors of SSI in patients who underwent elective laparotomy in the general surgery department of a tertiary care hospital in India. Methodology: This is an observational cross-sectional retrospective study, conducted over 5 years from January 1, 2015, to December 31, 2019. A total of 112 patients who underwent elective laparotomy in the department of general surgery, were enrolled in the study. Data collection was done from hospital case records and discharge summaries of patients. Results and Discussion: Out of the 112 patients, a total of 16 patients (14.29%) developed surgical site infections. Preoperative serum total protein (W-465.500, P 0.012) and length of hospital stay (W=1235.000, P≤0.001) were found to have a significant association with surgical site infection. Age, gender, smoking, comorbidity, class of surgical wound and, preoperative albumin did not show any significant association with the development of SSI. Escherichia coli was the predominant organism isolated in culture. Conclusion: Measures to curtail SSI can only be adopted after a thorough understanding of its prevalence and predictors. The characteristics and pattern of SSI will help identify prevalent organisms, their resistance pattern and will aid in formulating antibiotic policy tailor-made for the healthcare institution.

Keywords: Surgical site Infections, surgical wound infections, elective laparotomy, risk factors, prevalence, hospital acquired infections

Introduction

Surgical site infections (SSI) encompass 20-25% of all hospital-acquired infections with their prevalence ranging from 2.5 to 41.9% across the world [1, 2]. SSI impede post-operative recovery, increase the length of hospital stay and enhance the cost of healthcare. SSI also pose great challenges to the surgeon in terms of increased allocation of resources and manpower for combating the infection [3-9]. Healthcare institutions also have to bear the brunt in terms of the increased cost of healthcare [4]. Hence measures to prevent and minimize SSI are of utmost importance. Measures to curtail SSI can only be adopted after a thorough understanding of its prevalence and predictors. The prevalence and factors affecting SSI vary greatly from one country to another. The presence of efficient healthcare infrastructure, enhanced resources at disposal and, a better surveillance system for SSI may all be responsible for the variation in SSI noted between developed and developing nations. Risk factors for the development of SSI can be broadly categorized into patient related and surgery related factors. Patient related factors include nutritional status, preoperative albumin, presence of comorbid illness and immunosuppressive states. Surgical factors include emergent nature of surgery, duration, blood loss and contamination of operative field. This study is an attempt to characterize the risk factors for SSI in patients undergoing elective laparotomy. It will help to identify the magnitude of this healthcare problem and to take corrective measures. It will also aid the surgeon in identifying high-risk patients for SSI and hence plan pre-operative optimization.

Methods

The study is an observational cross-sectional retrospective study. The study duration was 5 years from 2015 to 2019. The study was conducted on patients who underwent elective laparotomy in the General surgery of a tertiary care hospital in India. All patients who underwent elective laparotomy between 2015 and 2019 who met the inclusion criteria were enrolled in the study.

Inclusion criteria

- Males and females of age 18 years and above.

- Patients who underwent elective laparotomy in General Surgery; 1. Open cholecystectomy; 2. Open CBD Exploration; 3. Stoma reversal; 4. Pericystectomy; 5. Freys procedure; 6. Resection and anastomosis of bowel stricture.

Exclusion criteria

- Patients undergoing laparotomy for malignancy.

- All patients whose medical records were not available.

Data collection

Data were obtained from case records and discharge summaries of patients who underwent elective laparotomy, who meet the inclusion criteria, after obtaining ethical clearance from the institutional ethics committee. Data regarding demographic parameters of the patient, preoperative variables, details of the surgical procedure performed and, the events in the postoperative course were recorded. A total of 321 patients underwent elective laparotomy during the 5 years. After excluding patients with malignancies and patients whose records were not available, 112 patients were enrolled in the study.

The indicators analysed in the study can be broadly divided into peroperative, intraoperative and postoperative. Preoperative variables included in the study were age, gender of the patient, presence of comorbid illness-diabetes, hypertension. The presence of addictions in the form of smoking, alcohol or both were analysed. The baseline blood investigations including complete blood counts, liver and renal function tests were also included in the study. Intraoperative data recorded include the surgical procedure performed and the class of surgical wound. Postoperative variable included was the length of hospital stay.

Post-operatively, the presence of surgical site infections and organisms isolated in culture sensitivity was noted. Surgical site infections were recorded according to the CDC classification of SSI. The patients were managed with antibiotic therapy according to the microbial sensitivity pattern and local wound care measures.

Statistical analysis

Mean and standard deviation was used for the analysis of quantitative data. Fischer's exact test and Wilcoxon-Mann-Whitney test were also used for the analysis of quantitative data Chi-square test was used to test the strength of association for categorical variables. No subgroup analysis was done in this study. Taking the confidence interval of 95%, the statistical significance was defined as a "*p*" value less than 0.05.

Ethics committee approval

The research was undertaken after obtaining approval from the institutional ethics committee, the approval number being 729/IEC/IM/NF/2020.

Results

Demography

A total number of 112 patients who underwent elective laparotomy over 5 years, were enrolled in the study. Sixty-seven patients (59.82%) were females and 45 patients (40.17%) were males. Of the 112 patients, 16 patients (14.29%) developed SSI in the postoperative period. Among the 16 patients who developed surgical site infection, 10 patients (62.5%) had superficial incisional surgical site infection, 4 (25%) developed deep incisional SSI and 2

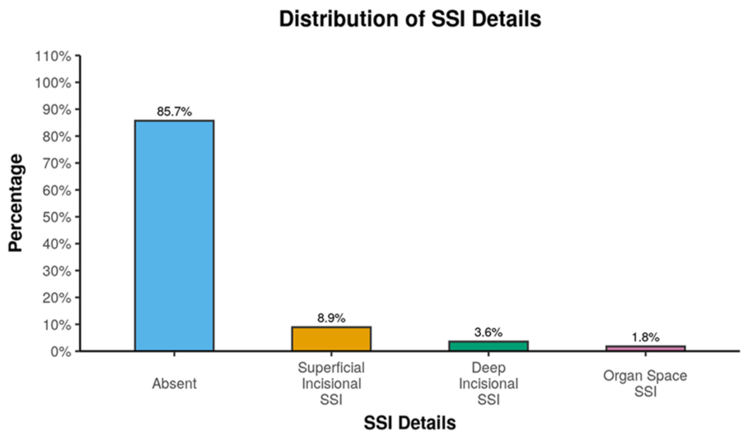

Figure 1. Percentage distribution of superficial incisional SSI, deep incisional SSI and, organ space SSI.

patients (12.5%) had organ space SSI. The percentage distribution of superficial incisional SSI, deep incisional SSI and, organ space SSI is shown in **Figure 1**.

*Risk factors of SSI (**Table 1**)*

Age and gender: The mean age of patients who developed SSI was 42.58±15.19 years. Forty-four (39.3%) patients were male and 68 (60.7%) patients were female. There was no significant association between age and the development of SSI. There was no statistically significant difference in age between patients who developed SSI and those who did not (p 0.215). A significant association between SSI and the gender of the patient (Chi-square test) also could not be identified in the study.

Comorbidity: Nearly 12.5% of the patients who developed SSI had an underlying comorbid illness, while 87.5% of the patients did not have any comorbidity. The most common comorbidity encountered was diabetes mellitus. The correlation, however, was not statistically significant (p 0.546).

Substance use: Substance abuse was noted in 12.5% of patients who developed SSI, 6.2% of the patients having a history of smoking and, 6.2% patients with a history of alcohol intake. There was no statistically significant association between substance abuse and the development of SSI (p 0.588).

Preoperative haemoglobin: The mean hemoglobin in the SSI group was 12.10 g/dl (3.6). There was no statistically significant association between preoperative hemoglobin levels and development of SSI in the post-operative period (p 0.093).

Total protein: There was a statistically significant difference in total protein levels (W-465.500, P=0.012), patients with SSI having lower median total protein compared to patients who did not develop SSI. A cut-off value of total protein ≤5.88 g/dl, predicts SSI with a sensitivity of 44% and a specificity of 92% (see **Figure 2**).

Serum albumin: The mean serum albumin of patients who developed SSI was 3.68 g/dl compared to 3.89 g/dl in patients who did not develop SSI. The association however was not statistically significant (W=638.000, P 0.281).

Length of hospital stay: The mean length of hospital stay in the SSI group was 28.25 days, while it was 13.82 days in patients who did not suffer from SSI. A statistically significant association was noted between the length of hospital stay and the development of SSI (W=1235.000, P≤0.001).

Type of surgery: Out of the 16 patients who developed SSI, 8 patients had a clean surgical wound while 8 had a clean-contaminated class of surgical wound. However, no significant association could be found between SSI and the surgical wound class.

Micro-organism in culture

Microbial growth was noted after 48 hrs of incubation in 15 patients (93.75%) while culture was sterile in one patient (6.25%). A single organism was isolated from the culture in 13 patients (86.66%), while 2 patients (13.33%) had polymicrobial growth. Five of the patients (33.3%) tested positive for E. coli, 3 (20.0%) patients for Klebsiella, two (13.3%) of the participants showed growth of dual organisms, one (6.7%) of the patients had Citrobacter, one patient (6.7%) demonstrated ME CONS, 1 (6.7%) patient had Methicillin sensitive coagulase-positive Staphylococcus, 1 (6.7%) patient had MRSA and one patient (6.7%) had pseudomonas isolated from culture. The type of SSI,

Table 1. Association between SSI and all parameters evaluated

PARAMETERS	SSI Present (n=16)	SSI Absent (n=96)	*P*-value
Age (Years)	43.88±13.73	42.36±15.47	0.7711
Gender			0.4773
Male	5 (31.2%)	39 (40.6%)	
Female	11 (68.8%)	57 (59.4%)	
Presence of any comorbidity	2 (12.5%)	18 (18.8%)	0.7332
Diabetes (Present)	2 (12.5%)	4 (4.2%)	0.2042
Hypertension (Present)	0 (0.0%)	9 (9.4%)	0.3542
Substance Use			0.2202
None	14 (87.5%)	88 (91.7%)	
Smoking	1 (6.2%)	5 (5.2%)	
Alcohol Use	1 (6.2%)	0 (0.0%)	
Smoking + Alcohol	0 (0.0%)	3 (3.1%)	
Type of Surgery			0.3183
Clean	8 (50.0%)	60 (63.2%)	
Clean Contaminated	8 (50.0%)	35 (36.8%)	
Haemoglobin (g/Dl)	12.10±2.36	12.06±1.80	0.8581
TLC (10^3/cu.mm)	10.08±4.14	9.34±4.32	0.4081
Platelet Count (Lacs/Cu.mm)	2.13±0.97	2.67±1.36	0.1111
Urea (mg/Dl)	20.67±6.65	26.08±12.94	0.0731
Creatinine (mg/Dl)	0.68±0.22	0.72±0.33	0.9141
S. Sodium (mEq/L)	134.94±4.02	136.33±4.12	0.2154
S. Potassium (mEq/L)	3.89±0.46	3.98±0.51	0.4764
S. Calcium (mg/Dl)	8.44±0.81	8.57±0.80	0.5654
Total Protein (g/Dl)	6.24±1.27	7.13±1.03	0.0121
S. Albumin (g/Dl)	3.68±0.65	3.89±0.74	0.2811
Length of Hospital Stay (Days)	28.25±17.89	13.82±8.63	<0.0011

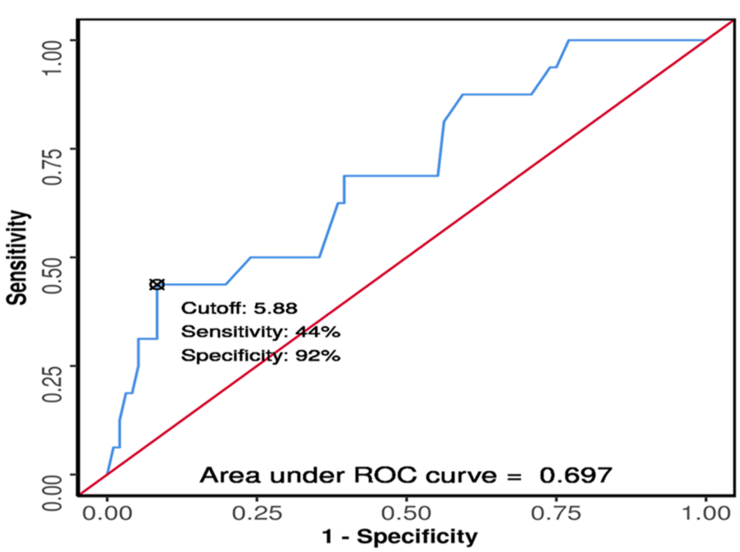

Figure 2. ROC Curve Analysis Showing Diagnostic Performance of Total Protein (g/Dl) in Surgical site infection.

microbial pattern and, resistance pattern observed in the study are described in **Table 2**.

Discussion

Surgical site infections are the third most common complication noted in the postoperative period [10]. The overall incidence of surgical site infection noted in our study was 14.29%, with incisional SSI alone being 12.25%. This observed rate was higher than the 12.5% SSI rate recorded by Kumar A et al. in 2017 in a retrospective study evaluating SSI rates in emergency and elective surgeries during a year [11]. The SSI rates

Table 2. Distribution of type of SSI, microbial pattern and, their resistance pattern

SSI	Mean ± SD||Median (IQR)||Min-Max||Frequency (%)
SSI (Present)	16 (14.3%)
SSI Details	
Absent	96 (85.7%)
Superficial Incisional SSI	10 (8.9%)
Deep Incisional SSI	4 (3.6%)
Organ Space SSI	2 (1.8%)
The organism on Pus Culture	
E. coli	5 (33.3%)
Klebsiella	3 (20.0%)
Dual Organism	2 (13.3%)
Citrobacter	1 (6.7%)
ME CONS	1 (6.7%)
Methicillin sensitive coagulase-positive staphylococcus	1 (6.7%)
MRSA	1 (6.7%)
Pseudomonas	1 (6.7%)
Sensitivity	
Meropenem, Doripenem	2 (16.7%)
Amikacin, Imipenem	1 (8.3%)
Amikacin, Imipenem, Doripenem	1 (8.3%)
Amikacin, Gentamicin	1 (8.3%)
Amoxyclav, Amikacin, Gentamicin	1 (8.3%)
Ampicillin, Ertapenem, Gentamicin	1 (8.3%)
Clinda, Tetra, Linezolid, Erythromycin	1 (8.3%)
Colistin	1 (8.3%)
Doxycycline	1 (8.3%)
Linezolid, Gentamicin	1 (8.3%)
Piperacillin Tazobactam	1 (8.3%)

in our study were lower than those observed in a cohort of emergency and elective laparotomy patients (22.2%) in a tertiary hospital in Israel [12]. The observed incisional SSI rates were higher than those noted by Tang M D et al. (3%) in a study conducted on patients undergoing elective resection of the colon in the United Kingdom [13]. The higher SSI rates observed in our study could be attributed to the poor pre-operative nutritional status of patients combined with the delayed presentation thereby increasing the morbidity and risk of postoperative complications.

Superficial incisional SSI constitute the major bulk of SSI noted in our study, 10 out of 16 patients (62.5%), followed by deep incisional SSI (4/16 patients-25%) and organ space SSI (2/16 patients-12.25%).

The mean age of patients who developed SSI in this study was 43.88 years, with 37.5% patients belonging to the 31-40 years age group. Among the patients who developed SSI, 31.2% were males and 68.8% were females. The major proportion of patients enrolled in the study also belonged to the same age group. This could have contributed to the higher preponderance of SSI observed in that group. Increasing age has been observed as a risk factor for the development of SSI by several studies [14]. The relation between age and increased incidence of SSI could be attributed to the greater number of comorbid illnesses associated with increasing age. The higher female preponderance noted could be attributed to females forming the bulk of the study population (60.7%). Male gender has been recorded as an independent risk factor for SSI in patients undergoing gastrointestinal and general surgical procedures [15]. The observed results of gender relationship with SSI however were variable in different types of surgeries, with female preponderance being noted in some [16]. The gender differences noted in the development of SSI in previous studies may be partly due to the gender-related risk factors contributing to the same [17]. Thus, it is difficult to arrive at a consensus regarding gender predisposition for SSI and further studies are required for the same. A statistically significant association could not be noted between age, gender and, development of SSI in our study.

Approximately 12.5% of patients with SSI had diabetes while only 4.2% of patients without SSI had diabetes as a comorbid illness. In our study, no significant association was found between diabetes and the development of SSI. Diabetes has been proposed as an independent risk factor for the development of SSI in a systematic review and meta-analysis [18]. In this systematic review, diabetes mellitus was found to be significantly associated with SSI in spine, cardiac and colorectal surgery. However, even in this systematic-review very few studies showed a significant independent association of diabetes with SSI [18].

The mean total Protein (g/Dl) was 6.24 (SD-1.27) in patients who developed SSI while the mean total Protein (g/Dl) was 7.13 in patients without SSI. Preoperative serum total protein (W-465.500, P 0.012) was found to be significantly associated with the risk of development of SSI in our study. The association between preoperative total protein and SSI risk has not been explored previously in elective laparotomy to the best of our knowledge. Low serum albumin level has been evaluated as a risk factor for SSI. Decreasing serum albumin in the perioperative period was found to be associated with complications in laparotomies in other studies [19]. Length of hospital stay was found to be significantly associated with Surgical site infection (W 1235.000, P<0.001) in our study. A longer hospital stay of 28.25 days was recorded in the SSI group, while it was 13.82 days in patients who did not suffer from SSI. An additional hospital stay of nearly 14 days was observed in the SSI group in our study. This is higher than the average 6.5 days of increased hospital stay noted in patients with SSI [4]. However, an additional hospital stay ranging from 7-24 days was recorded in some patients who developed SSI following varied surgical procedures, both elective and emergency [20-26]. The varied observations possibly suggest differences in recovery time from SSI in various surgical procedures, the nutritional status of the patient combating the infection and, varying treatment principles for combating SSI in different healthcare scenarios.

Smoking, preoperative hemoglobin, class of surgical wound were not found to be significantly associated with the development of SSI.

Conclusion

The incidence of surgical site infections observed in our study was 14.29% with Escherichia coli being the predominant organism isolated from aerobic cultures. Preoperative total protein and length of hospital stay were found to have a significant association with the risk of development of SSI. The risk factors associated with SSI and their strength of association will help identify its crucial predictors. This will provide valuable information regarding the magnitude of the healthcare problem and help adopt corrective measures. Thorough knowledge of predominant microbial flora and their resistance pattern can pave the way to the formulation of tailormade antibiotic policy for the healthcare institution. It will also aid the surgeon in identifying high-risk patients for SSI and hence plan optimization before surgery which is invaluable in elective procedures.

Limitations

The study being a retrospective one, data regarding SSI type and other parameters were record-based. Patients with malignancies and other immunocompromised states who underwent elective laparotomy were excluded. Intraoperative risk factors for SSI like duration of surgery and blood loss were not included in this study. A more extensive study enrolling a greater number of patients and all parameters which may influence SSI development is necessary. This will help to identify all the risk factors of SSI, and take necessary preventive actions and measures to curtail SSI like institutional antibiotic policies.

Disclosure of conflict of interest

None.

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