Original Article

A Prospective Study of Surgical Site Infection with its Risk Factors and Their Correlation with the NNIS Risk Index

Abstract

Background: Surgical site infection (SSI) is the third most commonly reported nosocomial infection, accounting for 10%–40% of all nosocomial infections and is a major cause of postoperative morbidity. Knowledge of factors related to SSI can help in reducing its incidence and related morbidity, which in many studies is shown to account for 38% of all infections in surgical patients. Lack of extending nosocomial infection surveillance programme and prevention measures in countries like India is viewed as a major challenge for the future. **Objectives:** The aims of this work were (1) to study the SSI rate in patients undergoing both elective and emergency abdominal surgery and SSI with CDC, and NNIS risk index; and (2) to assess SSI along with body mass index (BMI), glycaemic status, smoking and duration of pre-operative hospital stay of patients. **Materials and Methods:** In total, 300 patients who underwent elective and emergency abdominal surgery were enrolled in the study as per inclusion and exclusion criteria. SSI with CDC's NNIS risk index were analysed considering BMI, glycaemic status, smoking and duration of pre-operative hospital stay of patients. **Results:** In total, 300 cases of abdominal surgeries (elective and emergency) were analysed, out of which 60 cases were diagnosed to have SSI as per the criteria **Conclusion:** This study demonstrated that there is a significant increase in SSI with increasing NNIS score that is, the greater the NNIS score, the greater the risk of SSI. With an increase in age, BMI, glycaemic index and preoperative hospital stay, the risk of SSI increases. Smoking and associated comorbidities also increase the risk of SSI.

Keywords: *NNIS, risk factors, SSI, surgical site infection, wound discharge*

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Introduction

Surgical site infection (SSI) is the third most reported nosocomial infection, accounting for 10-40% of all nosocomial infections and is a major cause of postoperative morbidity.[1] It is the commonest and the most troublesome complication of wound healing.

In the United States, an estimated 27 million surgical procedures are performed each year.[2] The National Nosocomial Infection Surveillance System (NNIS) established in 1970, monitors reported trends in nosocomial infections in the United State's acute care hospitals. Based on these reports, SSI accounts for 14% to 16% of all nosocomial infections among hospitalised patients.[3] Indian studies report the rates of SSI to range from 6.1%–25% in abdominal surgeries.[4]

SSI is responsible for the increase in the duration of hospital stay, which results in social, physical, mental and economic trauma to patients and their families. Other clinical outcomes of SSIs include scars that can be hypertrophic or keloids which are cosmetically unacceptable. These scars can cause persistent pain and itching, restriction of movement (particularly when it is over joints) and a significant impact on the emotional state of the patient.

Surgical practice has seen dramatic changes over the past 30 years. It has evolved from an open procedure to a minimally invasive technique. This advancement, coupled with the growing attention and advancements in the field of hospital infection prevention, which has mainly taken place in countries with adequate resources, has led to a significant drop in hospital infections in those countries with adequate resources. Many countries including India have ineffective hospital infection prevention programmes due to lack of resources. Only few studies have been conducted in these countries due to limited health budgets.[5]

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Knowledge of factors related to SSI can help in reducing its incidence and related morbidity, which in many studies is shown to account for 38% of all infections in surgical patients.[6] Implementation of nosocomial infection surveillance programme and prevention measures in countries like India is viewed as a major challenge for the future.

So, this study was conducted to evaluate the factors associated with SSI along with its association with NNIS risk factor and risk factor index for SSI surveillance which can be effective in reducing the morbidity due to SSI in the near future.

Aims and objective

- To study the SSI rate in patients undergoing both elective and emergency abdominal surgery and correlate the SSI with CDC's NNIS risk index.
- To assess the association of SSI with body mass index (BMI), glycaemic status, smoking and duration of pre-operative hospital stay of patients.

Materials and Methods

This prospective observational study was conducted in the Department of Surgery, Post Graduate Institute of Medical Sciences and ESI Model Hospital, Basaidarpur, New Delhi for 2 years. Patients who underwent elective and emergency surgeries and fulfilled the inclusion and exclusion criteria were enrolled in the study.

Definitions

➢ Surgical site was considered to be infected according to the definition by CDC (centre for disease control) and NNIS.

NNIS parameters

Point 0 – For ASA grade 1/ 2, wound class 1/2 and operation lasting less than T hours

Point 1 – For ASA grade 3/ 4/5, wound class 3/4 and operation lasting over T hours

*T hours (75th percentile for the procedure)

NNIS risk index

Risk of SSI with Score 0 = 1.5%, Score 1 = 2.9%, Score 2 = 6.8%,Score 3 = 13%

➢ The wounds were classified according to the wound contamination class system.

(Class 1 – Clean, Class 2 – Clean-Contaminated, Class 3 – Contaminated, and Class 4 – Dirty-Infected)

Inclusion criteria

- All patients undergoing elective and emergency abdominal surgeries.
- Age >18 years

Exclusion criteria

- Patients who are already on antibiotic therapy for >1 week.
- Patients undergoing re-operations.

Methods for data collection

Postoperative and management-related factors (type of procedure, duration of surgery, findings and contamination level) were noted in detail. The surgical sites were examined on the 2nd postoperative day and then daily for pain, redness, warmth, swelling and type of discharge (serous/ purulent). Patient-related factors like BMI, glycaemic status, smoking, duration of pre-operative hospital stay of patients and intraoperative surgical findings related factors were also noted.

Post-discharge examination of the surgical site was performed for all patients in the out-patient clinic (initially weekly then monthly basis) for any evidence of SSIs. This surveillance was periodically done using the NNIS surgical surveillance components up to 90 days after discharge in order to detect SSIs that may have appeared after discharge (one year in cases of implants).

Sample Size

Using the formula for observational study where Z1-α/2 at 5% type I error is 1.96, P = 25% from previous study, d = 0.05

$$\frac{Z1\text{-}\alpha/22P(1\text{-}P)}{d^2}=288$$

Minimum sample size of 288 patients was required but 300 patients were enrolled considering the attrition and loss to follow-up of patients.

Statistical analysis

Statistical analysis was done using the SPSS program for Windows, version 17.0. Continuous variables were presented as mean ± SD, and categorical variables were presented as absolute numbers and percentage. Data were checked for normality before statistical analysis. Normally distributed continuous variables were compared using the unpaired t test, whereas the Mann–Whitney U test was used for those variables which were not normally distributed. Categorical variables were analysed using both the chi-square test and Fisher's exact test. For all statistical tests, a P value less than 0.005 was considered statistically significant.

Results

A total of 300 cases of abdominal surgeries (elective and emergency both) were analysed, out of which 60 cases were diagnosed to have SSI as per the criteria, and following observations were made.

Incidence of SSI

In our study, the incidence of SSI in abdominal surgeries (elective and emergency) was 20%.

SSI in different age groups

The total study population was 300 cases (n = 300). The following observations were made among different age groups [Table 1].

Total number of patients below 40 years was 153, out of which 24 patients had SSI (16%), while patients above 40 numbered 147, out of which 36 patients had SSI (24%).

There was a gradual rise in SSI with advancing age.

Gender correlation

In females, 20.97% developed SSI as compared to 19.32% in male patients. The *P* value was 0.016 which is insignificant statistically [Table 2].

Type of abdominal surgical procedure

In this study different abdominal surgeries were included as mentioned in Table 3.

Incidence of SSI among elective and emergency surgery

The total number of patients who underwent elective surgery was 216 (72%) out of which 34 (15.74%) patients developed SSI. while the total number of patients who underwent emergency surgery was 84 (28%) out of which 26 (30.95%) patients developed SSI [Table 4]. *P* value was significant that is, <0.0001.

Effect of BMI on SSI

A higher incidence of SSI (22.22%) was noted in overweight and obese patients (100%) as compared to normal BMI patients (17.42%). *P* value was significant that is, 0.0002 [Table 5].

Table 1: Incidence of SSI among different age groups

Age group (years)	SSI		No infection	Total
	Superficial	Deep		
≤ 20 years	0(0%)	2(14.29%)	12(85.71%)	14(100%)
21-30 years	1(1.67%)	8(13.33%)	51(85%)	60(100%)
31-40 years	5(6.33%)	8(10.13%)	66(83.54%)	79(100%)
41-50 years	11(18.03%)	6(9.84%)	44(72.13%)	61(100%)
51-60 years	8(16.67%)	3(6.25%)	37(77.08%)	48(100%)
61-70 years	4(11.76%)	3(8.82%)	27(79.41%)	34(100%)
>70 years	(0%)	1(25%)	3(75%)	4(100%)
Total	**29(9.67%)**	**31(10.33%)**	**240(80%)**	**300 (100%)**

Table 2: Co relation between gender and SSI

Gender	SSI		No infection	Total	*P* value
	Superficial	Deep			
Male	11(6.25%)	23(13.07%)	142(80.68%)	176(100%)	0.016
Female	18(14.52%)	8(6.45%)	98(79.03%)	124(100%)	
Total	**29(9.67%)**	**31(10.33%)**	**240(80%)**	**300 (100%)**	

Table 3: Type of abdominal surgical procedure

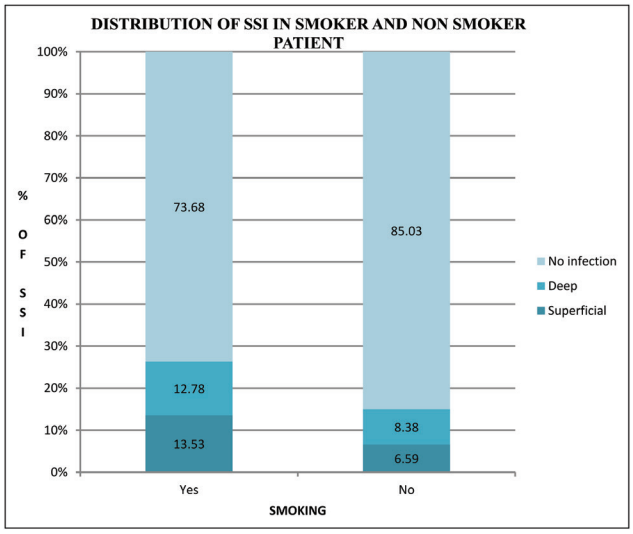
S.NO	Surgical procedure done	Number of surgeries	Percentage (N = 300)
1	Open Cholecystectomy	75	25%
2	Abdominal Perineal Resection	3	1%
3	Cystolithotomy	3	1%
4	Distal Gastrectomy	2	0.67%
5	Exploratory Laparotomy	29	9.67%
6	Feeding Jejunostomy	1	0.33%
7	Stoma Closure	3	1%
8	Lap Converted Open Cholecystectomy	6	2%
9	Nephrectomy	7	2.33%
10	Open Appendectomy	47	15.67%
11	Open Chole + Open Mesh Hernioplasty	2	0.33%
12	Open Mesh Hernioplasty	120	40.33%
13	Partial Cholecystectomy + Gastrojejunostomy+Resection Anastomosis	1	0.33%
14	Excision	1	0.33%

Table 4: Incidence of ssi among elective and emergency surgery

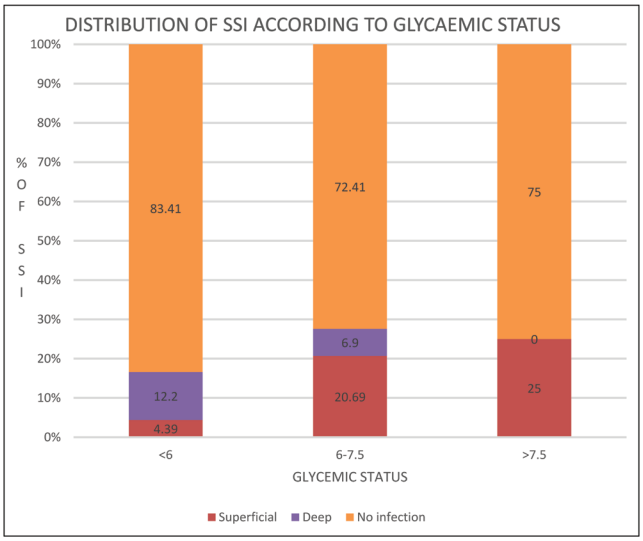
Procedure	SSI		No infection	Total	*P* value
	Superficial	Deep			
Elective	26(12.04%)	8(3.7%)	182(84.26%)	216(100%)	<0.0001
Emergency	3(3.57%)	23(27.38%)	58(69.05%)	84(100%)	
Total	**29(9.67%)**	**31(10.33%)**	**240(80%)**	**300 (100%)**	

Table 5: Co relation between BMI and SSI

BMI	SSI		No Infection	Total	P value
	Superficial	Deep			
Normal	8(5.16%)	19(12.26%)	128(82.58%)	155(100%)	0.0002
Overweight	20(13.89%)	12(8.33%)	112(77.78%)	144(100%)	
Obese	1(100%)	0(0%)	0(0%)	1(100%)	
Total	29(9.67%)	31(10.33%)	240(80%)	300 (100%)	



Graph 1: Correlation between smoking and SSI



Graph 2: Correlation between glycaemic status and SSI

Effect of smoking on SSI

On analysis it was found that SSI (26.31%) was more common in smokers as compared to non-smokers. *P* value was significant that is, <0.0001 [Graph 1].

Effect of glycaemic status on SSI

For HbA1c < 6, SSI was 16.59% (non-diabetic patients)

For HbA1c 6-7.5, SSI was 27.59% (diabetic patients)

For HbA1c > 7.5, SSI was 25% (uncontrolled diabetes mellitus)

Above data shows that the rate of SSI increases with increasing value of HbA1c. *P* value < 0.0001 which is significant [Graph 2].

Effect of pre-operative stay on SSI

Patients operated on the same day (emergency cases) were 88 (29.33%), and the number of patients who stayed for two days pre-operatively was 118 (39.33%), while a stay of three days pre-operatively was noted in 95 (31.66%) patients. Two patients had a 5- and 6-day pre-operative stay [Graph 3].

SSI rate significantly increased with increasing in pre-operative stay as *P* value is significant which is <0.0001[Graph 3].

Significance of NNIS score in SSI

For NNIS score 0, SSI rate was 10.04% (22 SSI in 219 patients), while for NNIS score 1, SSI rate was 46.83% (37 SSI in 79 patients). Moreover, 50% SSI rate was noted in patients with NNIS score 2 (1 SSI in 2 patients), showing that the rate of SSI increased with NNIS score. *P* value is significant (<0.0001) [Table 6].

Effect of comorbidity on SSI

Total number of comorbid patients were 53 (17.66%) while 247 (82.33%) patients did not have any comorbidity. SSI rate (32.08%) was higher in comorbid patients as compared

to SSI (17.41%) in non-comorbid patients. *P* value is significant (<0.0001).

Wound class and SSI

In 233 patients with class 1 wound (clean), SSI rate was 14.59%.

In 30 patients with class 2 wound (clean-contaminated), SSI rate was 10%.

In 30 patients with class 3 wound (contaminated), SSI rate was 53.33%.

And in 7 patients with class 4 wound (dirty), a 100% SSI rate was noted.

SSI rate increased significantly with increase in class of the wound (*P* value= <0.0001) [Graph 4].

Pattern of microorganism growth

Staphylococcus aureus was the most common organism which was isolated in 21 patients (35%). The second most common was *E. coli,* which was isolated in 15 patients (25%), followed by *Klebsiella* in 9 patients (15%), *pseudomonas* in 8 patients (13.33%), *enterococcus* in 5 patients (8.3%) and *Acinetobactor* in 2 patients (3.33%).

Discussion

This was a prospective study of 300 cases that had undergone abdominal surgery in our hospital, and were followed up from the day of operation, to 90 days after discharge and one year in case of implants.

Rate of surgical site infection

The SSI rate for 300 cases in present study was 20%.

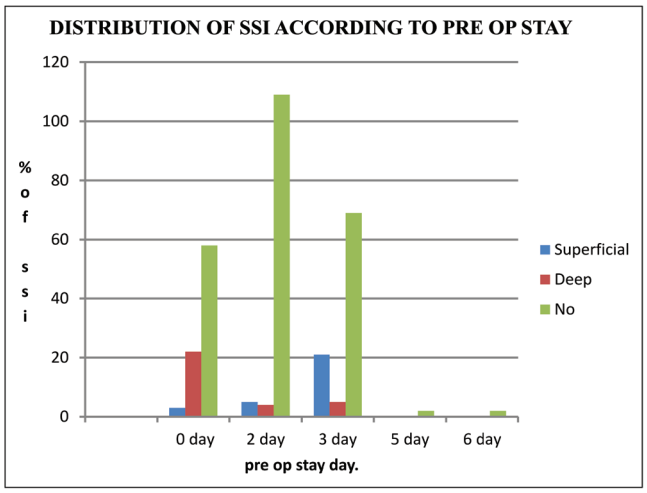
Different studies from India has shown the SSI rate to vary from 6.09% to 38.7%.[6] The infection rate in Indian hospitals is much higher than that in other countries; for instance in the USA, it is 2%–5%.[7]

The higher infection rate in Indian Government hospitals may be attributed to high patient load, lower socioeconomic status of patients in general surgery setting and lack of attention towards the basic infection control measures and basic hygiene. Table 7 shows incidence in various other study settings.[6,8-12]

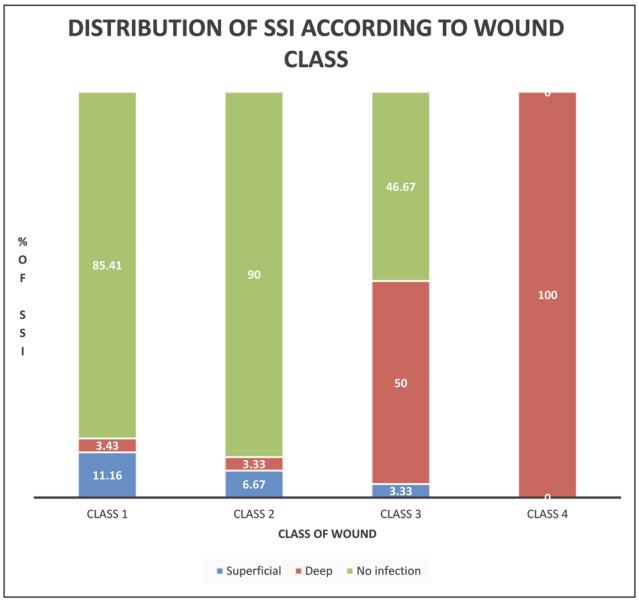
Effect of age on SSI

The SSI showed a gradual rise from 16% in below 40 years to 24% in above 40 years age group. There was a significant increase in SSI with an increase in age, which was similar to results in a study by Rajanikanth *et al.*[13]

Similar findings were demonstrated by Sattar *et al.*[14] who observed that SSI rates were highest in the age group above



Graph 3: Correlation between preop stay and SSI



Graph 4: Correlation between wound class and SSI

Table 6: Co relation between nnis and SSI

NNIS SCORE	SSI		No infection	Total	*P* value
	Superficial	Deep			
0	14(6.39%)	8(3.65%)	197(89.95%)	219(100%)	<0.0001 HS
1	14(17.72%)	23(29.11%)	42(53.16%)	79(100%)	
2	1(50%)	0(0%)	1(50%)	2(100%)	
Total	**29(9.67%)**	**31(10.33%)**	**240(80%)**	**300 (100%)**	

Table 7: Rate of SSI in different studies

Author	Number of Surgeries	Year	Country	Infection
Cruse and Foord[8]	62939	1980	Canada	4.7%
Anvikar et al.[9]	3280	1999	India	6.09%
Umesh et al.[10]	114	2008	India	30.7%
Mahesh C B et al.[6]	418	2010	India	20.9%
Siddalinga et al.[11]	100	2011	India	15%
Mekhla et al.[12]	169	2019	India	39%
Present study	300	2020	India	20%

55 years (36.4%). High SSI rates in older age groups are due to co-morbid conditions and poor immune response.[15]

The high SSI rate in older persons in our study may thus be due to the aforementioned reasons.

Gender distribution and SSI

In this study, SSI was noted more in female patients (20.97%) in comparison to male patients (19.32%). Our results are in concordance with results shown in a study by Adeyinka *et al.*[16]

In our literature review, no clear consensus could be drawn. Some studies have shown that male patients have a higher incidence of SSI than female patients while in others, female patients had a higher incidence of SSI.[16,17]

SSI in emergency vs. elective surgery

The SSI rate in elective surgeries was found to be 15.74% which increased to 30.95% in emergency cases. Similar results were found by Kumar *et al.*,[18] in which 17.7% of SSI was associated with emergency surgeries and 12.5% of SSI with elective surgeries.

The higher rate in emergency surgeries can be multifactorial; lack of preoperative preparation, debilitated condition of patient, underlying infective pathologies and more frequency of contaminated and dirty wounds in emergency surgeries.

In elective surgeries the patients are generally well nourished and have adequate time for preoperative preparation and optimisation of unfavourable factors. This helps in better outcome of these patients; however, SSI can happen owing to the underlying pathology or intraoperative factors also.

BMI and SSI

In this study, patients who had a high BMI were associated with a high incidence of SSI. In patients with normal BMI, SSI incidence was lower (17.42%) in comparison to overweight patients (22.22%) and obese patients (100%). Similar results were found by Naveen *et al.*[19]

Obesity increased the risk of SSI nearly fourfold among patients who underwent operations in the United Kingdom from 2006 to 2010.[17] Overall, the SSI risk increased with increasing BMI.

Smoking and SSI

In this study, patients who were smokers were more predisposed to develop SSI when compared to non-smokers (SSI rate = 26.31% in smokers and 14.97% in non-smokers). Similar results were found by Huquan *et al.*[20] (smoker = 5.4% and non-smoker = 4.2%) in 2019.

Glycaemic index

In this study, it was seen that patients with poorly controlled blood glucose levels had higher SSI rate in comparison to patients having good control over blood glucose levels. Patients who had HbA1c level <6 SSI rate were 16.59%, whereas in patients with HbA1c level between 6 and 7.5 SSI rate was 27.59% and patients with HbA1c more than 7.5, SSI rate was 25%. To prevent SSI in DM patients, we recommend lowering the HbA1c to <7.0% before surgery.[21]

In a study by Mishra *et al.*[22] they found that even in non-diabetic patients when there is stress-induced perioperative hyperglycaemia, the rate of SSI was more as compared to patient with normal blood sugar levels.

Pre-operative stay

Prolonged preoperative hospital stay was the independent predictor of SSI.[23] Mundhada *et al.*[24] found that patients who had a preoperative stay of more than 1 week were more associated with SSI (43%).

Similar results were seen in this study, where patients who were operated within two days, had lower (7.61%) SSI rate in comparison to patients with pre-operative stay more than 2 days (27.6%).

NNIS risk index

The work of Haley *et al.*[25] investigators at the Centre for Disease Control and Prevention (CDC), reported on a composite risk index used in the National Nosocomial Infections Surveillance (NNIS System).

In our study it was found that SSI rate is 10.04% for NNIS score 0, 46.83% for NNIS score 1 and 50% for NNIS score 2. Hence, SSI rate increases with an increase in NNIS score. Similar results were found in study done by Patel[26] (NNIS 0 = 0%, NNIS 1 = 15.7%, NNIS 2 = 52.5%) in 2011.

Co-morbidities

Obesity, Diabetes mellitus and hypertension were the most frequent comorbidities associated with surgical wound infection reported worldwide.

In a study by Mejía *et al.*,[27] a higher incidence of SSI was found in patients suffering from diabetes mellitus (25.3%) and patients of low immunity group (43.4%). In our study, we found that SSI rate (32.08%) was much higher in comorbid patients as compared to non-co-morbid patients in which the SSI rate was 17.41%.

Wound class

In our study, we found that the SSI rate increases with increased contamination of the wound (dirty > clean).

Similar result was found by Mekhla *et al.*,[12] in which clean and clean-contaminated wounds had an SSI rate of 23.7% and dirty wounds had an SSI rate of 60.9%. SSI rate in contaminated and dirty cases were significantly higher (RR 2.57, CI 1.52–4.31).

SSI is higher in class 3 and 4 wounds because of the spillage of GI tract contents in peritoneal cavity, acute inflammation in the tissues with or without purulent collection encountered intraoperatively and delayed presentation increases the contamination and devitalised tissues.

Conclusion

This study demonstrated that there is a significant increase in SSI with increasing NNIS score. With the increase in age, BMI, glycaemic index and preoperative hospital stay, the risk of SSI increases. Smoking and other comorbidities also increase the risk of SSI.

Certain contributing factors to SSI can be rectified which can prevent or decrease the incidence of SSI. The optimisation of the patient before surgery is desired in cases planned for elective surgery and in case of emergency surgeries, proper resuscitation should be done to improve the outcome and prevent SSI.

In this study, it was found that the scoring of this index accurately assessed the risk and therefore we recommend the use of this risk index for assessing and managing patients.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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