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Original Research Article

A prospective study on risk factors for development of surgical site infections at a tertiary care hospital: a two years study

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ABSTRACT

Background: Surgical site infections (SSI) are the second most common Nosocomial infections after urinary tract infections accounting to 20-25% of Nosocomial infections worldwide. Based on the depth of the infections, SSI is classified by CDC as superficial incisional, deep incisional and organ/space. The development of SSI is dependent upon multiple factors like class of wound, immune status, type of surgery, type of anesthesia; surgical techniques etc and are interplay of multiple factors. Objective of the present study was conducted in identifying the predictors, risk factors and incidence rates of SSI at a tertiary care hospital. The study also identifies the causative bacterial pathogens and their antibiotic susceptibility pattern

Methods: A prospective cross-sectional study was conducted for a period of two years by department of general surgery involving all patients who underwent surgery, and pre-operative, intra operative and risk factors of the cases were collected using standardized data collection form. Specimens from the infected wounds were collected and processed for isolation of pathogens. Antibiotic susceptibility of pathogens was done using standard guidelines.

Results: The incidence of SSI in present study was 25.34% with 81.58% superficial SSI and 18.42% deep SSI. Laparotomy was the common procedure and 63.2% of cases were females and 41-60 years was the most common age group. *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Escherichia coli* were the common pathogens and were sensitive to carbapenems, vancomycin and linezolid. Significant association was observed with presence of pre-morbid analysis, presence of drain, use of povidone iodine alone and development of SSI.

Conclusions: In present study the incidence of SSI was significantly high in this hospital and associated with premorbid illness, duration of surgery, presence of drain and use of drain at site of surgery. *Staphylococcus aureus* was the common pathogen and incidence of MRSA is higher than many other reports. A continuous monitoring and surveillance of patients with a predefined protocol will help in early identification of cases with risk of development of SSI. A feedback of appropriate data to surgeons is highly recommended to reduce the SSI rate in developing countries.

Keywords: Laparotomy, MRSA, *Staphylococcus aureus*, Surgical site infections

INTRODUCTION

Despite considerable research and advances in surgical techniques, sterilization practices and technological improvements infections at the surgical site still remains a grave problem. Surgical site infections (SSI) are the second most common Nosocomial infections after urinary tract infections accounting to 20-25% of Nosocomial infections worldwide.[1] Globally the incidence of SSI is rising continuously and are a serious cause of increased

mortality, morbidity and leading to increased hospital stay and economic burden in developing countries.[2] In relation to the patient SSI are associated with increased pain, cost and loss of life. Based on the depth of the infections, SSI is classified by CDC as superficial incisional, deep incisional and organ/space. Any infection that occurs within 30 days of surgery is classified as SSI, however in cases with implanted prosthesis the time may be extended to one year. The development of SSI is dependent upon multiple factors like class of wound, immune status, type of surgery, type of anesthesia; surgical techniques etc and are interplay of multiple factors.[3] The origin of pathogens responsible for development of SSI can be of endogenous like microbial flora of the gut or exogenous like from the hospital personnel or from infected patients.

The risk factors, predictors for development of SSI are variable from place to place and dependent upon the patient's factors and site and type of surgery. Developing an accurate protocol in predicting the cases that develop SSI will be helpful in identification and management of SSI and also in reducing the incidence rates of SSI. Modifiable risk factors in developing SSI like diabetes, hypertension, and smoking can be focused in decreasing the incidence and with better patient outcome.[4] Other factors which can be modifiable include pre and intra operative factors like type of anesthesia, duration of surgery and antimicrobial prophylaxis administered during surgery.

The present study was conducted in identifying the predictors, risk factors and incidence rates of SSI at a tertiary care hospital. The study also identifies the causative bacterial pathogens and their antibiotic susceptibility pattern.

METHODS

A prospective cross-sectional study was conducted at Narayana Medical College and Hospital a tertiary care hospital by Department of general surgery in association with department of infection control for a period of two years from January 2014 to December 2015. The study was approved by the institutional ethical committee and all the guidelines were followed as per the ethical protocol.

Inclusion criteria

All the cases who underwent surgery in the department and whose period of stay was more than one day were included in the study. All patients of all age groups and gender who underwent surgery with an open visible incision (Laparotomy, excisional biopsy, appendicectomy, cholecystectomy, thyroidectomy, mastectomy, amputations etc) were included in the study. The sample size of the study was 250. The study particulars were explained to the participants of the study and written informed consent was obtained. Patient characteristics, preoperative, intra operative and post-operative data were collected in a standardized form. All the necessary laboratory investigations and HIV testing was performed in all the cases of the study.

Study design

Details of the patient characteristics (age, sex, medical history, past history of surgery etc), type of surgery, wound class, type of anesthesia, duration of surgery, antimicrobial prophylaxis, pre-operative hospital stay, and total hospital stay was recorded. Patient was followed from the day of surgery to discharge and 30 days post operatively. Surgical wound was inspected on 1st day of dressing and weekly thereafter until day of discharge. SSI were identified and classified as per the guidelines of the CDC.[5] Pus or discharge from the infected wound was collected and transported to the central microbiology laboratory and processed immediately as per the standard guidelines. The bacterial isolates were identified by standard biochemical tests and antibiotic susceptibility of the isolates were performed by Kirby- Bauer disk diffusion test and interpreted by CLSI guidelines.[6]

Data analysis

All the collected data was entered in a Microsoft excel spread sheet and verified. Analysed data was entered in SPSS software version 17.0 and further analysed. Chi square test was performed to determine the significant associations and p value less than 0.005 was considered significant.

RESULTS

The present study was conducted at Narayana Medical College and Hospital by Department of General surgery. A total of 900 surgeries of different types were conducted in the study period of which 300 cases that fulfilled the inclusion criteria were enrolled in the study.8 cases that could not follow up were excluded from the study.

Table 1: Type of procedure and SSI rate in every procedure.

Surgical procedure	SSI positive	SSI negative	Total
Appendicectomy	10	38	48
Laparotomy	20	44	64
Herniotomy	13	31	44
Thyroidectomy	4	22	26
Mastectomy	5	16	21
Cholecystectomy	5	17	22
Spleenectomy	2	12	14
Amputation	4	10	14
Excisional biopsy	4	8	12
Open prostatectomy	5	6	11
Others	4	20	24
Total	76 (25.34)	224(74.66)	300

The incidence of SSI in present study was 25.34% (76/300) of which 62 (81.58%) were superficial SSI and 14 (18.42%) were deep seated SSI. The mean time taken for development of SSI was 4.82 days with a range of 3-8 days. Females outnumbered the males in the study with an incidence of 63.2% of SSI and in males with 36.8%. The mean age of the study population was 36 years with a standard deviation of 16.28. Mean age of females in the study was 41 years and males 38 years. Statistically significant association was observed in the incidence of SSI between males and females in present study (p value<0.001) (Table 2).

Table 2: Patient factors associated with SSI.

Variable	SSI		P value
	Yes (n) (%)	No (n) (%)	
	N= 76	N= 216	
Age (year)			
<21 years	12 (15.8)	54 (25)	0.4
21-40	14 (18.4)	50 (23.1)	0.62
41-60	28 (36.8)	74 (34.3)	0.15
>60 years	22 (28.9)	38 (17.6)	0.21
Sex			
Male	28 (36.8)	92 (42.6)	0.01
Female	48 (63.2)	124 (57.4)	0.42
Pre-morbidity			
Diabetes	24 (31.6)	20 (9.3)	0.02
HTN	12 (15.8)	44 (20.4)	0.05
HIV	4 (5.3)	4 (1.9)	<0.001
None	36 (47.4)	148 (68.5)	<0.001
Pre-morbidity			
Absent	36(47.37)	174 (80.6)	
Present	40 (52.63)	42 (19.4)	<0.001
Smoking			
Yes	48 (63.2)	32 (14.8)	<0.001
No	28 (36.8)	184 (85.2)	

In present study, 108 cases (36%) had a pre-morbid illness, diabetes in 40.74% of cases (44/108), hypertension in 51.85% (56/108) and HIV in 7.41% (8/108). The SSI rates in cases with pre-morbid illness were 52.63% (40/76) and without pre-morbid illness was 47.37% (36/76). The rates of SSI in cases without pre-morbid illness was 19.4% (42/216) and a statistically significant association was found between the rates of SSI among cases with and without pre-morbid illness. (P value <0.001) As illustrated in Table 2, the incidence of SSI among smokers in present study was 63.2% (48/76) and among non-smokers was 14.8% (32/216) and was found statistically significant (P value <0.001).

Ninety two cases were administered antimicrobial prophylaxis with a ceftriaxone and amikacin, ceftriaxone alone, Ceftriaxone and metronidazole based upon the type of surgery performed. All the cases of intestinal surgeries were administered ceftriaxone with metronidazole. The timing of administration of antimicrobial prophylaxis ranged from 1-6 hours with a mean of 2.4 hours and standard deviation of 0.38 hours. The rate of SSI among cases who received antimicrobial prophylaxis and who did not receive was 15.8% and 84.2% and there was no significant association (P value=0.08).

The rates of SSI as per Classification of ASA in class I, II and III are 25.32%, 30% and 85.7%. (P value<0.001) 75% of the cases were scrubbed with Iodine and alcohol and 25% were scrubbed with Iodine alone for skin preparation. The rates of SSI among patients scrubbed with iodine alone and a combination of iodine and alcohol were 62.16% and 12.96% which was statistically significant. (P value<0.001) In present study, there was no statistical significance between hair removal and incidence of SSI (Table 3).

Table 3: Preoperative factors associated with SSI.

Variable	SSI		P value
	Yes (n) (%)	No (n) (%)	
	N= 76	N= 216	
Preoperative duration of hospitalization			
≤7 days	41(53.9)	140(64.8)	0.42
≥7 days	35(46.1)	76 (35.2)	0.05
Antimicrobial prophylaxis			
Yes	12(15.8)	80 (37)	
No	64(84.2)	136 (63)	0.08
ASA (American society of anesthesiologists)			
I	40(52.6)	158(73.1)	
II	24(31.6)	56(25.9)	<0.001
III	12(15.8)	2 (0.9)	<0.001
Hair removal			
Yes	5 (6.6)	48 (22.2)	0.04
No	71(93.4)	168(77.8)	0.08
Skin preparation			
Iodine alone	46(60.5)	28 (13)	<0.001
Iodine and alcohol	28(36.8)	188 (87)	

The rates of SSI in cases of emergency and electively operated cases were 24.5% and 29.5% and without any significance. (P value=0.41) In cases of type of anesthesia induced, the incidence of SSI was higher in cases spinal anesthesia (32.6%) than in cases of general anesthesia (23.3%). In present study, drain was used in 96 cases in which SSI was observed in 41.2% of cases and not found in 32.4% and a statistically significant association was found. (P value <0.001) The incidence of SSI in cases of surgery with <3 hours of duration were 20.2% and in cases with >3 hours of duration were 41% and statistically significant association was observed with duration of operation and incidence of SSI in present study. The duration of operation in present study ranged from 2 hours to 9 hours with a mean duration of 1.9 hours and standard deviation of 0.38 hours. In present study, out of 300 surgeries performed 196 were clean, 76 clean-contaminated and 20 were contaminated. The rates of SSI

in clean surgeries were 24.5%, clean contaminated 26.3% and contaminated 40% (Table 4). There was no association between the type of suture material used in the surgery and development of SSI in present study. Nylon was the most common (57.3%, 172/300) suture material used in present study.

Table 4: Intra operative factors associated with SSI.

Variable	SSI		P value
	Yes (n) (%) N= 76	No (n) (%) N= 216	
Nature of operation			
Elective	50 (65.8)	154 (71.3)	0.41
Emergency	26 (34.2)	62 (28.7)	0.28
Type of anesthesia			
General	48 (63.2)	158 (73.1)	0.12
Spinal	28 (36.8)	58 (26.9)	0.24
Use of drain			
Yes	28 (36.8)	68 (31.5)	<0.001
No	48 (63.2)	148 (68.5)	
Wound classification			
Clean	48 (63.2)	148 (68.5)	0.51
Clean contaminatec	20 (26.3)	56 (25.9)	0.002
Contaminated	8 (10.5)	12 (5.6)	0.41
Suture			
Nylon	44(57.9)	128 (59.3)	0.004
Vicryl	12 (15.8)	14(6.5)	0.02
Silk	20 (26.3)	74(34.3)	0.14
Duration of operation			
<3 hours	44 (57.9)	174 (59.3)	
≥3 hours	32 (42.1)	42 (19.4)	0.001

In present study, out of 76 cases which were positive for SSI, specimens were collected and sent for isolation of aerobic pathogens. 64 of the specimens produced pure growth with a single isolate and 12 produced a mixed growth with two isolates. *Staphylococcus aureus* (32) was the commonest gram-positive isolate in the study and *Klebsiella pneumoniae*, *Escherichia coli* was the common gram-negative isolates in the study. Out of 32 *Staphylococcus aureus*, 18 were Methicillin resistant. 12 of the *Escherichia coli*, 14 of *Klebsiella pneumonia*e and 4 of Acinetobacter sp. were extended spectrum β-lactamase producers. Gram negative isolates exhibited maximum sensitivity to carbapenems (100%) and gram positive to vancomycin and linezolid (100%).

DISCUSSION

SSI are the second most common type of adverse events occurring in hospitalized patients after surgery and one of the serious complications. The incidence of SSI differs from hospital to hospital and from one geographic location to another.[7] In present study, SSI rate was 25% which is comparable with the studies of Syed Mansour Razavi who reported the incidence of 24% in his study.[8] In present study, most of the cases were in the age group of 41-60 years and with a clear female preponderance. Similar findings were reported by Agarwal S in his study.[9] The incidence of SSI was higher in females (27%) than in males (24%) in present study. These findings were similar to the findings of Rao AS but contrary to the reports of Anvikar AR who reported higher incidence of SSI in males than females.[10,11]

This could be explained by the facts that females are more prone due to risk factors like anemia, poor immune status and associated diabetes mellitus and others. Diabetes mellitus and malnutrition are associated with a poor impact on wound healing due to impairment of tissue oxygenation and local hypoxia via vasoconstriction.[12] As described in many studies the rates of SSI are higher in patients of HIV than in Non-HIV patients and was found statistically significant. HIV affects the immune status of the individual and CD4 counts are an important predictor for the assessment of development of SSI.[13]

Smoking has an adverse effect on wound healing making the surgical cases more prone for development of infections. In present study 60% of the smokers developed SSI which is similar to the findings of Culver DH et al who reported higher incidence of SSI in his study but contrary to the findings of Anderson DJ et al who reported only 25% of SSI rates in his study among smokers.[14,15]

The clinical relevance of present study is patients with pre-existing diseases such as hypertension, malnutrition, HIV and diabetes are more prone and at high risk of develop SSI than in other normal patients. Findings of present study are similar to many published reports earlier and signify the association of risk factors in present study with the development of SSI. Prolonged duration of surgery and prolonged pre-operative hospitalization are associated with increased risk of SSI in present study. However significant statistical association was observed with duration of surgery and prolonged pre-hospitalization failed to reach significant association (P value >0.001). These findings were similar to the reports of Altemeier WA et al who also reported that prolonged surgery with ≥3 hours is associated with a risk of 7% in incidence of SSI than in surgeries with <3 hours duration.[16]

In present study it was observed that the rate of SSI was significantly associated with ASA classification and class 3 ASA was associated with more risk of development of SSI. These findings were similar to Haynes SR et al.[17] In present study it was observed that incidence of SSI was higher in cases where povidone iodine was used alone than in cases with a combination of iodine and alcohol. This is due to shorter duration of action of iodine and also action of iodine is inhibited by protein in blood and serum. The type of anesthesia used depends upon the type of surgery, status of the patient and various other preferences.

Classification of surgical wounds is considered a good predictor in assessment of SSI. In present study, incidence of SSI was more in cases of contaminated wounds than clean and clean contaminated wounds. The report of present study coincides with the findings of Ercole FF et al and was also found statistically significant.[18] Use of perioperative antibiotics did not have any impact on reduction of SSI in present study and was also found not statistically significant. This can be explained by the fact that absence of clear antibiotic policy in administration during surgery. Most of the studies earlier reported higher incidence of SSI in patients with presence of post-surgical drains, arteriovenous catheters and cannulas. The same finding was observed in present study and a significant association was observed in cases with the presence of drain and development of SSI.[19]

The common isolates of present study were *Staphylococcus aureus, Klebsiella pneumoniae* and *Escherichia coli* which are reported as most common causative agents in many studies conducted universally. The incidence of MRSA in present study was 58% and ESBL producing gram negative bacteria were 22% as compared in many studies. The emergence of multi drug resistant strains is posing a serious threat in management of SSI. Gram negative pathogens were sensitive to Carbapenems, and gram positive to vancomycin and linezolid in present study.[20]

CONCLUSION

To conclude, in present study the incidence of SSI was significantly high in this hospital and associated with premorbid illness, duration of surgery, presence of drain and use of drain at site of surgery. Staphylococcus aureus was the common pathogen and incidence of MRSA is higher than many other reports. Hence a continuous monitoring and surveillance of patients with a predefined protocol will help in early identification of cases with risk of development of SSI. A feedback of appropriate data to surgeons is highly recommended to reduce the SSI rate in developing countries.

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