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Surgical site infection in abdominal surgeries: a retrospective analysis of risk factors, microbial flora and resistance pattern

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Abstract

Background and Objectives: Surgical Site Infections (SSI) are prevalent complications following surgical procedures globally. However, there is a relative scarcity of published data on SSI patterns in developing countries like India. This study aims to assess the incidence, risk factors, and antibiotic profiles of SSI pathogens, addressing this research gap.

Materials & methods: In this retrospective study, a total of 441 patients who were admitted to the surgical department of a tertiary care teaching hospital in Central India from January 2016 to December 2016 were included. Patient data was gathered from hospital records using a structured data collection form. Statistical analysis was performed using SPSS software version 20.0, with a P-value of less than 0.05 indicating statistical significance.

Results: The incidence of SSI in our study was 11.11 %, with associated risk factors including age, ASA class, surgeon's expertise, wound classification, prolonged surgery duration (>2 h), extended hospital stay, transfusion, and emergency surgical procedure. Klebsiella spp, Escherichia coli, Proteus spp, Acinetobacter, Staphylococcus aureus, and coagulase-negative staphylococci were the isolated pathogens, exhibiting varying levels of antibiotic resistance. Amikacin and Imipenem showed almost 100% sensitivity against all pathogens

Conclusion: The incidence rate SSI fell within standard international ranges. However, approximately 50% of the isolates exhibited multi-drug resistance, limiting treatment options for patients with SSI. To address this, regular surveillance of pathogens and antibiotic susceptibility, alongside the strict implementation of protocols for antibiotic administration and operating room regulations, becomes crucial in mitigating the impact of SSI caused by drug-resistant bacterial pathogens.

Key words: Surgical Site Infection, Klebsiella, Amikacin, Drug Resistance, India.

Introduction

Surgical Site Infections (SSI) are infections that occur subsequent to invasive surgical procedures and are among the most commonly reported hospital-acquired infections (HAIs) [1, 2]. SSI represents a specific category of HAI that emerges in connection with the surgical site following a surgical intervention [3]. Presently, the definition of SSI encompasses infections that manifest within 30 days following the operation in the absence of an implant, or within one year in case any implant is present [4].

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SSI can lead to various negative outcomes, including higher morbidity and mortality rates, prolonged hospital stays, increased hospital readmissions, the need for reoperation, and escalated healthcare expenses [5, 6]. Numerous studies conducted worldwide have highlighted the association between different surgical specialties and elevated costs following the occurrence of SSI [7–9].

In the USA, SSI represents a significant complication, occurring in approximately 2 to 5% of patients undergoing surgery and affecting around 300,000 to 500,000 surgical procedures annually. The financial burden associated with SSI surpasses $1.6 billion for the healthcare system [10, 11]. Furthermore, SSI is the prevailing surgical complication in both developed and developing countries [12].

The worldwide prevalence of Healthcare-Associated Infections (HAI) is expected to be around 1.4 million at any particular time. The incidence of HAI varies significantly among countries as well as surgical procedures, but it is conservatively estimated to arise in at least about 2% of surgeries [10]. In low and middle-income countries (LMIC), the incidence of SSI may be up to four times higher compared to high-income countries [11]. Notably, in developing countries, various studies have reported higher SSI rates compared to developed countries, with incidence stretching from 11% to 18% [10, 12].

A recent prospective study conducted in a developing country reported an overall incidence of SSI at 10.9% [13]. The limited availability of published reports concerning risk determinants for SSI, microbial pathogens involved, and their antibiotic profiles has had a detrimental effect on the prevention and treatment of these infections. Consequently, there is a pressing need to investigate the prevalence of SSI, the underlying causes for its development in postoperative patients, and the common microorganisms associated with SSI in Central India. This research would contribute to enhancing our understanding of SSI and aid in developing effective strategies for its prevention and management.

Aims & objectives

The objective of this study was to determine the prevalence of SSI, identify the associated risk factors, investigate the causative bacterial agents responsible for SSI, and assess their antimicrobial susceptibility patterns. By accomplishing these objectives, the study aimed to contribute valuable insights into the burden of SSI and provide essential information for improving prevention and management strategies in surgical patients.

Material & methods

This retrospective and descriptive study enrolled a total of 441 patients who were admitted to surgical departments at a tertiary level medical teaching hospital in Central India from January 2016 to December 2016. Ethical approval for the study was acquired from the institutional ethics committee. The study focused on patients aged 18 years and above who underwent elective or emergency surgery and developed wound infections within the specified duration of the study. Patients who underwent additional operation in one month preceding the study duration were excluded. All data was gathered from hospital records using a structured data collection form in order to decide the incidence of SSI.

A comprehensive patient history was obtained for each case, encompassing details such as age, gender, co-morbid conditions, blood transfusion, antibiotic therapy, and preoperative hospital stay. The surgical procedures were categorized into clean, clean-contaminated, contaminated, and dirty. Additionally, relevant data regarding associated risk factors (e.g., diabetes, obesity), utilization of prophylactic antimicrobial agents, and the type and duration of surgery were collected. Wound infections were assessed based on the classification system provided by the Centers for Disease Control and Prevention (CDC), which includes superficial infections, deep infections, and infections involving organs or spaces.

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Wound swabs and/or pus aspirates were obtained from the clinically infected surgical sites following standard laboratory procedures for specimen collection. Upon arrival at the microbiology laboratory, the swabs or aspirates were inoculated onto MacConkey agar and 5% Sheep Blood agar (BA) using a rolling technique and streaking from the primary inoculums. The agar plates were then incubated aerobically at 37 °C for 24–48 hours. Bacterial identification was carried out according to established guidelines [16].
The antibiotic susceptibility testing was conducted using the standard disc diffusion method, following the guidelines set forth by the Clinical and Laboratory Standards Institute (CLSI). The procedures strictly adhered to the CLSI guidelines [17]. After measuring the zone diameters, the bacterial isolations were classified as sensitive, intermediate, or resistant. Detailed laboratory data, including gram stain results, culture findings, bacterial identification, and antimicrobial susceptibility, were recorded on a data sheet.
All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 21.0 for Windows (SPSS, Inc., Chicago, IL). Descriptive statistics, such as counts and percentages, were employed to describe the demographic characteristics of the study subjects. The mean and standard deviation were calculated for quantitative variables, while qualitative data were compared using proportions. Bivariate analysis was performed using Chi-square ($\chi 2$) and Fisher's exact tests to assess the association between potential risk factors and their relationship with SSI. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1 presents the demographic characteristics of the study population. The mean age of the patients was 40.45 ± 15.97 years. The majority of the patients (56.24%) fell within the age range of 26-44 years, and the male patients accounted for 68.93% of the total. In terms of education, approximately half of the patients (55.56%) had completed primary school, while only a small percentage (3.40%) had achieved education beyond secondary level. Alcohol consumption was reported by 36.96% of the patients, whereas only 3.40% of the patients were smokers. The majority of the surgeries (61.01%) were orthopedic cases, followed by obstetrics cases (28.63%) and general surgery cases (7.35%).The analysis of SSI incidence in male and female patients revealed no statistically significant difference (p = 0.08).
The overall incidence of Surgical Site Infections (SSI) following surgery was determined to be 11.11% (49 out of 441 patients). All of these infections were categorized as superficial based on the CDC definition. It is important to note that no infections were identified within 30 days after the patients were discharged from the hospital.

Table 1: Socio-Demographic details of the study population

	Total (N = 441)		**With SSI (N=49)**		**Without SSI (N =392)**		**P Value**
	n	**%**	**n**	**%**	**n**	**%**	
Age (in years)							
≤ 25	71	16.10	8	15.31	63	16.07	< 0.05
26–45	248	56.24	40	81.63	208	53.06	
> 45	124	28.12	2	3.06	122	30.99	
Gender							
Male	304	68.93	39	79.59	265	67.60	0.08
Female	137	31.07	10	20.41	127	32.40	
Education Level							
Illiterate	72	16.21	1	2.04	71	17.98	< 0.05
Primary School	245	55.56	28	57.14	217	55.36	

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Secondary School	109	24.72	17	34.69	92	23.47	
Above Secondary	15	3.40	3	6.12	12	3.06	
Alcohol							
Yes	163	36.96	21	42.86	142	36.22	0.36
No	278	63.04	28	57.14	250	63.78	
Smoking							
Yes	15	3.40	2	4.08	13	3.32	0.78
No	426	96.60	47	95.92	379	96.68	

Table 2 displays the findings related to the participants' body mass index (BMI). The mean BMI of the participants was 23.37 ± 2.45 kg/m2, indicating a relatively healthy weight distribution among the patients. Out of the total number of operations, 213 were elective procedures, while 228 were emergency procedures.

Table 2: Clinico-procedural details of the study population

Variables	Total (N = 441)		With SSI (N 49=)		Without SSI (N 392=)		P Value
	n	%	n	%	n	%	
BMI(Kg/m^2)							
≤ 25	291	65.99	36	73.47	255	65.05	0.45
25–30	123	27.89	10	20.41	113	28.83	
≥30	28	6.24	3	6.12	25	6.25	
Type of Surgery							
Emergency	228	51.70	44	89.80	184	46.94	< 0.05
Elective	213	48.30	5	10.20	208	53.06	
Surgical Outcome							
Discharge	436	98.87	49	100.00	387	98.72	0.67
Death	5	1.13	0	0.00	5	1.28	

Table 3 presents the distribution of surgical procedures according to the performing surgeons and the severity of disease as measured by the American Society of Anesthesiologists (ASA) score. The surgeries were predominantly performed by licensed surgeons. The ASA score ranged from class I, representing patients in good health, to class IV, indicating severe systemic diseases that pose a continuous threat to life. The majority of patients fell into the class I category. Most of the operated patients, including those who developed Surgical Site Infections (SSI), were discharged from the hospital. However, five patients died.

Table 3: Analyses of surgical risk factors related with SSI

Variables	Total (N = 441)		With SSI (N 49=)		Without SSI (N 392=)		P Value
	n	%	n	%	n	%	
ASA score							
ASA I	317	71.88	22	44.90	295	75.26	< 0.05
ASA II-IV	124	28.12	27	55.10	97	24.74	
Wound class							
Clean and clean contaminated	429	97.28	44	89.80	385	98.21	< 0.05
Contaminated and dirty	12	2.72	5	10.20	7	1.79	
Type of Surgeon							
Surgeon	316	71.66	27	55.10	289	73.72	< 0.05
Resident	125	28.34	22	44.90	103	26.28	
Time of prophylaxis							

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≤ 15 min	63	14.17	6	12.24	57	14.41	0.88
15–30 min	371	84.13	43	87.76	328	83.67	
30 min-1 h	8	1.81	0	0.00	8	2.04	
Duration of surgery (hours)							
< 2	271	61.45	21	42.86	250	63.78	< 0.05
≥ 2	170	38.55	28	57.14	142	36.22	
Blood Transfusion							
No 266	399	90.36	33	67.35	366	93.24	< 0.05
Yes 28	43	9.64	16	32.65	27	6.76	
Number of persons in the OT room							
≤ 6	225	51.02	26	53.06	199	50.77	0.76
> 6	216	48.98	23	46.94	193	49.23	
Post-operative Hospital stay (days)							
≤ 14	370	83.90	11	21.43	360	91.71	< 0.05
> 14	71	15.99	38	77.55	33	8.29	

In order to assess the risk factors associated with Surgical Site Infections (SSI), a bivariate analysis was conducted, and the results are presented in Tables 2 and 3. This analysis revealed several statistically significant risk factors for SSI within the scope of this study. Firstly, patients classified as ASA class II and above demonstrated a significantly higher incidence of SSI compared to those classified as ASA class I. This indicates that higher ASA classification, indicative of poorer overall health and increased comorbidities, is associated with an elevated risk of SSI. Furthermore, when surgical procedures were categorized based on wound classification, contaminated and dirty wounds exhibited a higher incidence of SSI compared to clean surgical wounds. This finding underscores the importance of wound contamination as a risk factor for SSI. Moreover, procedures performed by licensed surgeons were found to be less likely to be associated with SSI compared to procedures performed by residents. This suggests that the experience and expertise of licensed surgeons may contribute to a lower risk of SSI. The duration of surgery was also observed to be a significant factor, with operations lasting more than two hours being more frequently related with SSI compared to shorter procedures. Prolonged surgical durations may increase the exposure time to potential pathogens, thus elevating the possibility of SSI. Additional factors that predicted the incidence of SSI included blood transfusion during surgery and a prolonged hospital stay of more than 14 days due to post-operative complications. These findings highlight the relevance of these risk factors in the development of SSI.

Swabs from all patients who developed Surgical Site Infections (SSI) were collected and subjected to culture and antibiotic susceptibility testing. Out of the 49 swabs, positive cultures were obtained from 47 of them. Table 4 provides an overview of the bacterial organisms identified in these positive cultures. Among the cultures with positive growth, the most frequently isolated organism was Klebsiella spp, followed by Escherichia coli and Proteus spp.

Table 4: Distribution of pathogens grown on SSI Swab samples

Microorganism	Total (N = 47)	
	n	%
Klebsiella spp	25	53.19
Escherichia coli	8	17.02
Proteus spp	5	10.64

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Acinectobacter	4	8.51
Staphylococcus aureus	3	6.38
Coagulase-negative staphylococci	2	4.26

As depicted in Table 5, the antibiotic sensitivity profiles of the organisms isolated from surgical incision sites in patients with SSI were examined. The pathogens exhibited a high level of resistance to amoxy-clavulanic acid, gentamicin, ciprofloxacin, and ceftriaxone, with only 46.7% sensitivity observed for ceftriaxone. However, two antibiotics, namely amikacin and imipenem, demonstrated excellent efficacy, as all tested isolates were found to be sensitive to both antibiotics, indicating a 100% sensitivity rate. These results highlight the limited effectiveness of commonly used antibiotics and emphasize the importance of appropriate antibiotic selection in the treatment of SSI.

Table 5: Antibiotic resistance pattern in SSI Swab samples

Antibiotic resistance	**Total (N = 47)**	
	n	**%**
Amoxy-clavulanic acid	45	96.71
Gentamicin	37	79.15
Ciprofloxacin	44	93.17
Ceftriaxone	27	56.67
Amikacin	0	0.00
Imipenem	0	0.00

Discussion

This study aimed to assess the burden of Surgical Site Infections (SSI) by investigating the incidence, risk factors, etiological bacterial agents, and their antimicrobial susceptibility pattern in a referral and tertiary healthcare institution located in Central India. The research sought to provide valuable insights into the prevalence and characteristics of SSI in this specific healthcare setting, contributing to a better understanding of the infection and informing strategies for its prevention and management.

The findings of this study are based on a sample of operated cases, with a majority of them being orthopedic cases. The overall incidence of SSI was found to be 11.11%, which is comparable to the average incidence of 11.8% reported in developing countries. Additionally, the incidence of SSIseen in our study was similar to a past study done in India, which stated an incidence rate of 11% [19]. However, it is worth noting that the incidence rates in this study were higher compared to several developed countries such as the United States, Europe, Germany, England, France, and Portugal, where the incidence rates ranged from 1.4% to 2.2%. These differences in incidence rates highlight variations in SSI prevalence across different healthcare settings and countries. The difference in the incidence rates of SSI between developed countries and developing countries, including India, can be attributed to various factors. These factors include inadequate infrastructure and resources in hospitals, leading to challenges in maintaining strict aseptic guidelines. Poor hygiene practices among patients can contribute to increased colonization of bacterial flora on the skin. Delayed presentation of patients to healthcare facilities may result in contaminated wounds. Additionally, overwhelmed emergency services due to high population burden can also contribute to the higher incidence of SSI in developing countries. These factors highlight the importance of addressing healthcare infrastructure, hygiene practices, and timely access to healthcare services to reduce the incidence of SSI in developing countries

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The findings of this study align with previous research that has identified several risk factors associated with SSI. These factors include age, ASA class, wound classification, surgeon's skill and experience, duration of surgery, blood transfusion, and emergency surgery. The incidence of SSI tends to increase with age, potentially due to a compromised immune response and the presence of other comorbidities. Patients with a higher ASA score, indicating a more severe systemic illness, are more likely to experience SSI, possibly due to impaired immune function in these individuals. Contaminated and dirty wounds are known to have a higher incidence of SSI, as they provide a favorable environment for bacterial growth and infection. Consistent with previous studies, the skill and expertise of the surgeon have a significant impact on SSI rates, with more experienced surgeons associated with lower SSI rates. These findings emphasize the importance of considering these risk factors in surgical practice to prevent and manage SSI effectively [4, 19].

Indeed, the duration of surgery is an important risk factor for SSI. Prolonged exposure of tissues to the surgical environment increases the chances of contamination and infection. Factors such as prolonged hypothermia and declining levels of antibiotics during lengthy surgeries further contribute to the risk. Additionally, a longer hospital stay provides more opportunities for bacterial colonization and subsequent development of SSI.

Patients who acquire blood transfusions in the course of surgical procedure also are at a higher threat of SSI. This can be attributed to the reduced hemoglobin levels in these patients, which may lead to tissue hypoxia and impaired wound healing, creating a favorable environment for infection. Emergency surgeries have been associated with an increased incidence of SSI as well. Inadequate preoperative preparation, lack of proper control of comorbidities (such as uncontrolled diabetes), and the higher frequency of contaminated or dirty wounds in emergency procedures all contribute to the heightened risk. Identifying and addressing these risk factors can help healthcare providers implement preventive measures and improve patient outcomes by reducing the incidence of SSI.

Although no significant difference was observed in the incidence of SSI in relation to factors such as the timing of prophylactic antibiotic administration, smoking, BMI, sex, and the number of staff during surgery, it is important to note that these factors can still have an impact on SSI rates. In a separate investigation, patient-related variables such as smoking habits, body mass index (BMI), lifestyle choices, and nutritional status have been observed to be linked with the body's ability to resist infections following surgery. Likewise, the intricacy of the surgical procedure itself is known to impact the duration of the operation and the likelihood of exposure to pathogens [21, 22].

The investigation also encompassed an assessment of the microorganisms responsible for SSI and their patterns of antimicrobial resistance. Notably, Klebsiella ssp exhibited the highest incidence rate at 55%, followed by Escherichia coli at 15%, and Proteus ssp at 12%. These findings diverge from those reported in other studies, where Staphylococcus aureus was identified as the primary causative agent of SSI. This contrast can be explained by the normal presence of S. aureus on the skin, enabling its entry into deeper surgical sites. However, the outcomes of this study align with the conclusions of other research, wherein Klebsiella ssp was identified as the predominant bacterial isolate [23, 24].

The variation observed in the distribution of bacteria causing SSI could be attributed to differences in the prevalent nosocomial pathogens in different healthcare settings, as well as variations in infection control and prevention policies implemented by countries and hospitals. While no definitive explanations exist for the high prevalence of Enterobacterial isolates in the present study, potential reasons could include fecal

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contamination resulting from inadequate personnel hygiene or contamination occurring post-procedure, which could potentially lead to outbreaks.

Our study revealed remarkably high resistance rates, ranging from 56.67% to 96.71%, among bacterial isolates responsible for SSI to commonly administered antibiotics. Notably, 56.67% of SSI cases exhibited resistance to ceftriaxone, which was prescribed as prophylaxis for all surgical procedures. Conversely, amikacin and imipenem were the only drugs demonstrating full effectiveness, with a 100% sensitivity rate against SSI-causing bacteria. The presence of multidrug-resistant bacteria in SSI has also been documented in other studies conducted in developing countries. This heightened resistance can potentially be attributed to the easy availability and inappropriate use of drugs within our hospital settings.

Conclusion

The incidence rate of SSI in our study was determined to be 11.11%, falling within acceptable international ranges. However, a concerning finding was that half of the isolates exhibited multi-drug resistance, limiting the available treatment options for patients with SSI. Statistical analysis demonstrated a significant association between SSI and factors such as wound class, longer duration of surgery and hospital stay, surgeon experience and grade, and emergency surgeries.

Therefore, it is crucial to establish periodic surveillance of bacteria and their antibiotic susceptibility patterns. Furthermore, the implementation of strict protocols for antibiotic administration and adherence to operative room regulations are essential measures in minimizing the burden of SSI caused by resistant bacterial pathogens. These proactive approaches can help combat the challenges posed by multi-drug resistant infections in the context of surgical site infections.

Conflicts of interest

None

Source of funding

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