ORIGINAL RESEARCH

An assessment of surgical site infections in elective and emergency abdominal surgeries: A prospective cohort study

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ABSTRACT
Background: Surgical site infections (SSIs) are a significant and persistent challenge in surgical practice, particularly in emergency abdominal surgeries. The current study aimed to evaluate the incidence of surgical site infections (SSIs) in emergency abdominal surgeries, identify the associated bacterial pathogens, assess their antibiotic resistance patterns, and examine risk factors contributing to SSIs.
Materials and Methods: This prospective study included 120 patients admitted to the surgical wards, divided into two groups: 60 undergoing emergency surgeries (Group A) and 60 undergoing planned surgeries (Group B). Preoperative and postoperative evaluations were conducted, and wound discharge samples were sent for culture and sensitivity testing. Data were analyzed using SPSS software, with statistical significance set at $p < 0.05$.
Results: SSIs were significantly higher in the emergency group (30.00%) than in the planned group (6.67%). The highest SSI rates in the emergency group were observed in dirty (30.77%) and contaminated (25.00%) wounds, compared to 12.00% in clean-contaminated and 3.33% in clean wounds in the planned group. Diabetes, anemia, and smoking were notable risk factors, with rates of 30.00%, 33.33%, and 30.00%, respectively, in the emergency group. Escherichia coli (47.62%) and Staphylococcus aureus (38.09%) were the predominant organisms, with Amikacin and Metronidazole demonstrating high efficacy.
Conclusion: Emergency abdominal surgeries had significantly higher SSI rates compared to planned surgeries, particularly in cases involving comorbidities, longer durations, and contaminated or dirty wounds. Optimized preoperative care, strict aseptic techniques, and targeted antibiotic therapy are essential to reduce SSI rates and improve outcomes.
Keywords: Surgical site infections, Emergency abdominal surgery, Antibiotic resistance, Wound classification, Risk factors

INTRODUCTION

Surgical site infections (SSIs) are a significant and persistent challenge in surgical practice, particularly in emergency abdominal surgeries. Defined as infections occurring at or near the surgical incision within 30 days of a procedure or within one year if an implant is placed, SSIs are among the most common postoperative complications, contributing to increased morbidity, prolonged hospital stays, and higher healthcare costs. Their occurrence in the context of emergency abdominal surgeries presents unique challenges due to the acute and often unpredictable nature of these cases, coupled with the compromised physiological state of patients requiring urgent intervention.[1] Emergency abdominal surgeries are frequently performed for life-threatening conditions such as perforated viscus, bowel obstruction, appendicitis, and abdominal trauma. These conditions are often associated with significant contamination of the peritoneal cavity, compromised tissue integrity, and the need for rapid surgical decision-making. Unlike elective surgeries, emergency procedures are often performed without optimal preoperative preparation, increasing the risk of complications, including SSIs. The urgency of these surgeries leaves little time for measures like adequate bowel preparation, optimization of comorbid conditions, or proper antiseptic skin preparation, all of which are critical in reducing the risk of infections.[2] The pathophysiology of SSIs in emergency abdominal surgeries is multifactorial. The presence of bacterial contamination in the abdominal cavity is one of the primary factors. Infections in these cases may arise from endogenous sources, such as the gastrointestinal tract, where a breach of the mucosal barrier allows enteric bacteria to invade sterile surgical sites. Additionally, exogenous sources, including surgical instruments, operating room environments, and healthcare personnel, can contribute to microbial contamination. The interplay between these factors, combined with the compromised immune status of many patients undergoing emergency surgery, creates a fertile environment for the development of SSIs.[3] Patient-related factors also play a crucial role in the susceptibility to SSIs. Many patients presenting for emergency abdominal surgery are already critically ill, with underlying conditions such as diabetes mellitus, chronic obstructive pulmonary disease, or immunosuppression that impair wound healing and immune defense mechanisms. Malnutrition, dehydration, and hypovolemia—common in emergency settings further exacerbate the body's ability to mount an adequate response to infection. Additionally, advanced age and obesity have been associated with higher rates of SSIs, reflecting the complex interplay of patient demographics and pre-existing health conditions in the development of postoperative complications.[4] Surgical technique and intraoperative factors also significantly influence the risk of SSIs. Prolonged operative times, extensive tissue handling, and the presence of devitalized tissue increase the likelihood of bacterial colonization and subsequent infection. The type of incision, method of closure, and the use of surgical drains or foreign materials such as mesh can also contribute to the risk of SSIs. In emergency abdominal surgeries, the need for rapid and often extensive surgical interventions can make it challenging to adhere to standard infection prevention protocols, further compounding the risk. The consequences of SSIs in emergency abdominal surgeries extend far beyond the immediate postoperative period. SSIs can lead to wound dehiscence, intra-abdominal abscesses, sepsis, and even mortality. Patients who develop SSIs often require additional surgical interventions, prolonged antibiotic therapy, and extended hospitalization, all of which contribute to increased physical, emotional, and financial burdens. From a broader perspective, SSIs place a significant strain on healthcare systems, consuming valuable resources and increasing costs.[5] Prevention of SSIs in emergency abdominal surgeries requires a multifaceted approach. Adherence to aseptic techniques, judicious use of prophylactic antibiotics, and meticulous surgical technique are essential components of infection control. Additionally, measures such as timely administration of antibiotics, maintenance of normothermia, and adequate oxygenation during surgery have been shown to reduce SSI rates. However, the unique challenges of emergency surgery such as time constraints, unanticipated complications, and the critical condition of patients demand tailored strategies to optimize outcomes in this high-risk population. Recent advances in understanding the pathogenesis of SSIs and the development of innovative infection prevention strategies offer hope for improved outcomes in emergency abdominal surgeries. For example, the use of negative pressure wound therapy (NPWT) on surgical incisions, antimicrobial-coated sutures, and intraoperative wound irrigation with antiseptic solutions has shown promise in reducing infection rates. However, the effectiveness of these measures in the emergency setting requires further investigation, given the unique challenges and variability of such cases.[6] Despite these advancements, SSIs remain a persistent problem, particularly in resource-limited settings where access to advanced surgical techniques, antibiotics, and infection control measures may be restricted. Addressing the burden of SSIs in emergency abdominal surgeries requires a comprehensive approach that includes improving surgical practices, enhancing patient care, and investing in infection control infrastructure. Education and training of healthcare personnel, along with ongoing research into novel prevention and treatment strategies, are essential to mitigate the impact of

SSIs and improve surgical outcomes.[7] Surgical site infections in emergency abdominal surgeries represent a complex and multifaceted challenge in surgical care. The combination of patient-related factors, the inherent contamination associated with abdominal procedures, and the urgency of emergency surgeries contributes to the high risk of SSIs in this population. While significant progress has been made in understanding and addressing this issue, continued efforts are needed to develop effective, evidence-based strategies to prevent and manage SSIs, ultimately improving outcomes for patients undergoing emergency abdominal surgeries.

AIM AND OBJECTIVES: The current study aimed to evaluate the incidence of surgical site infections (SSIs) in emergency abdominal surgeries, identify the associated bacterial pathogens, assess their antibiotic resistance patterns, and examine risk factors contributing to SSIs.

MATERIALS AND METHODS

Study Design: The present study was a prospective observational and cohort study.

Study Place*:* The current study was conducted at the Department of General surgery, Anugrah Narayan Magadh Medical College & Hospital, Gaya, Bihar, India.

Study Period: The study was carried out from July 2019 to June 2022.

Study Population

All patients admitted to the surgical wards (both elective and emergency cases) during the study period and meeting the inclusion criteria were enrolled using a convenience sampling method. All gave their written consent to participate in the study after being briefed on the study's purpose and methodology. A total of 120 patients participated in the current study.

Patients were divided into two equal groups of 60:

- **Group A (Emergency group)** included patients requiring urgent surgical interventions for conditions such as intestinal obstruction, penetrating abdominal injuries, ruptured appendix, gallbladder or intestinal perforations, abdominal trauma from road accidents, splenic injuries, pyoperitoneum, or obstructed hernias.
- **Group B (Elective group)** comprised patients scheduled for planned surgeries, including inguinal hernia repair, mastectomy for breast cancer, cholecystectomy, pseudo-pancreatic cyst treatment, and ventral hernia repair.

Ethical Consideration

The study was approved by the research and ethical committee of the ANMMCH, Gaya, Bihar.

Inclusion Criteria

- All patients give written informed consent and aged17 years and older,
- Patients with no prior history of surgical site infections (SSIs), and those with or without comorbidities such as diabetes, hypertension, anemia, smoking history, or other chronic illnesses were eligible for the study.
- Available for follow-up.

Exclusion Criteria

- The study excluded patients with late-onset SSIs (more than 30 days post-surgery),
- Patients age less than 17 years,
- patients undergoing repeat surgical procedures, individuals in an immunocompromised state or on immunosuppressive drugs or steroids, and those undergoing thoracic, obstetric and gynecological, orthopedic, or head surgeries.
- Uncooperative patients or patients who did not give consent and unable to attend follow-up.

Preoperative Assessment

Before surgery, patients underwent a detailed clinical evaluation to determine the onset, progression, and duration of symptoms such as abdominal pain, distension, nausea, vomiting, constipation, rectal bleeding, or abdominal lumps. A thorough physical examination was conducted to assess signs and vital parameters, including blood pressure and pulse rate. Abdominal tenderness, guarding, or rigidity were noted. Diagnostic imaging, such as upright abdominal X-rays, was performed to detect gas under the diaphragm, air-fluid levels, or foreign bodies. Additionally, abdominal ultrasonography was used to assess the liver and spleen condition, peritoneal fluid characteristics (hemoperitoneum /pyoperitoneum), appendix status, bowel obstruction, dilated loops, abdominal masses, and other relevant factors.

Postoperative Assessment

After surgery, patients were monitored for SSI symptoms, including erythema, swelling, discharge, tenderness, and elevated temperature at the incision site. Systemic symptoms such as fever, nausea, vomiting, and purulent discharge were also assessed. Wound discharge samples were sent for culture and sensitivity testing. For critically ill patients, complete blood counts and blood culture tests were performed. Wounds were managed with regular dressing using povidone-iodine and hydrogen peroxide solutions. Antibiotic therapy was guided by culture sensitivity results.

Statistical Analysis

The data obtained was subjected to statistical analysis using a Microsoft Excel spreadsheet and analysed using software Statistical Package for the Social Sciences (SPSS) 25.0 version. The data were represented in tables and graphs. The chi-square test was employed to determine the association between categorical variables. A confidence interval of 95% was used, with statistical significance set at a p-value less than 0.05.

RESULTS

The mean of Group A (60 patients) was 37.33 ± 13.08 years, whereas the mean of Group B (60 patients) was 41.92 ± 14.91 years, respectively. P-value for SSI infection difference between groups was 0.0022 (suggesting a statistically significant difference).

Table 1: Demographic Distribution Including Gender

Category	Group A (Emergency Group) - Total Patients	Group A (Emergency Group) - SSI (N/%)	Group B (Planned Group) - Total Patients	Group B (Planned Group) - SSI (N/%)	P-value
Age (In years)					
15-30	25	5/20.00%	20	2/10.00%	0.0022
31-45	20	8/40.00%	15	0/0.00%	
46-60	10	3/30.00%	15	1/6.67%	
≥60	5	2/40.00%	10	1/10.00%	
Total	60	18/30.00%	60	4/6.67%	-
Gender					
Male	45	14/31.11%	40	1/2.50%	0.119
Female	15	4/26.67%	20	3/15.00%	
Total	60	18/30.00%	60	4/6.67%	-

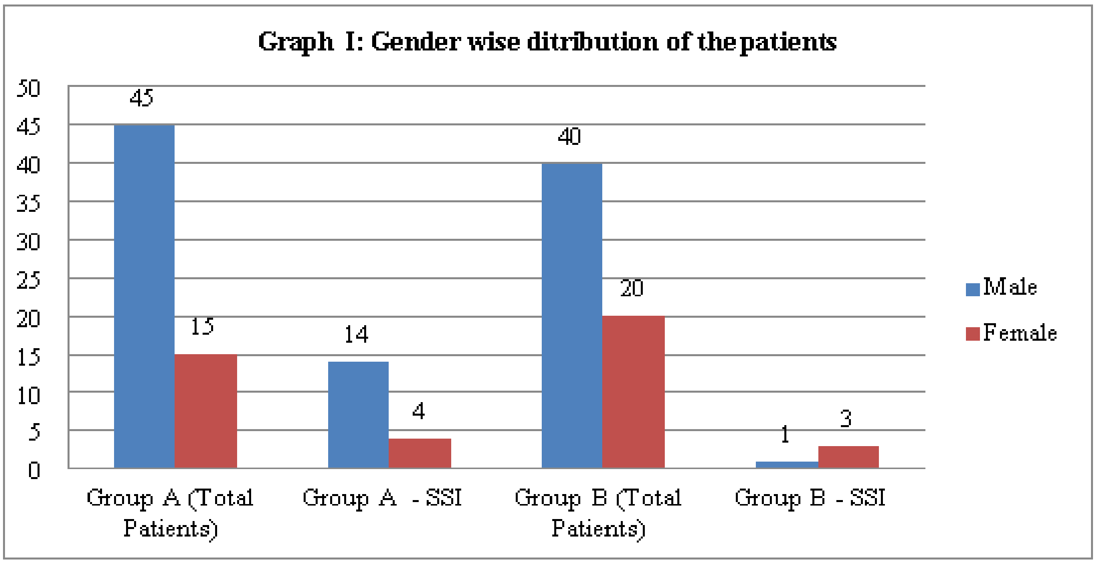

Table 1 and Graph I show the age and gender distribution of patients in both the emergency and planned surgery groups, along with SSI rates. Among patients aged 15–30 years, the SSI rate was 20.00% in the emergency group and 10.00% in the planned group. The highest SSI rate in the emergency group was in the 31–45 and ≥60 age brackets (40.00%), while in the planned group, the rates remained low, with a maximum of 10.00% in the ≥60 group. Gender-specific data indicate that male patients experienced more SSIs (31.11% in the emergency group and 2.50% in the planned group) compared to females, who had 26.67% SSIs in the emergency group and 15.00% in the planned group. This highlights a higher overall incidence of SSIs in emergency surgeries (30.00%) than planned surgeries (6.67%).

Table 2: Distribution of SSIs as per Comorbidities and Smoking Status

Comorbidities	Group A - Total Patients	Group A - SSI (N/%)	Group B - Total Patients	Group B - SSI (N/%)
Diabetes	10	3/30.00%	8	1/12.50%
Hypertension	15	2/13.33%	12	0/0.00%
Anemia	12	4/33.33%	10	2/20.00%

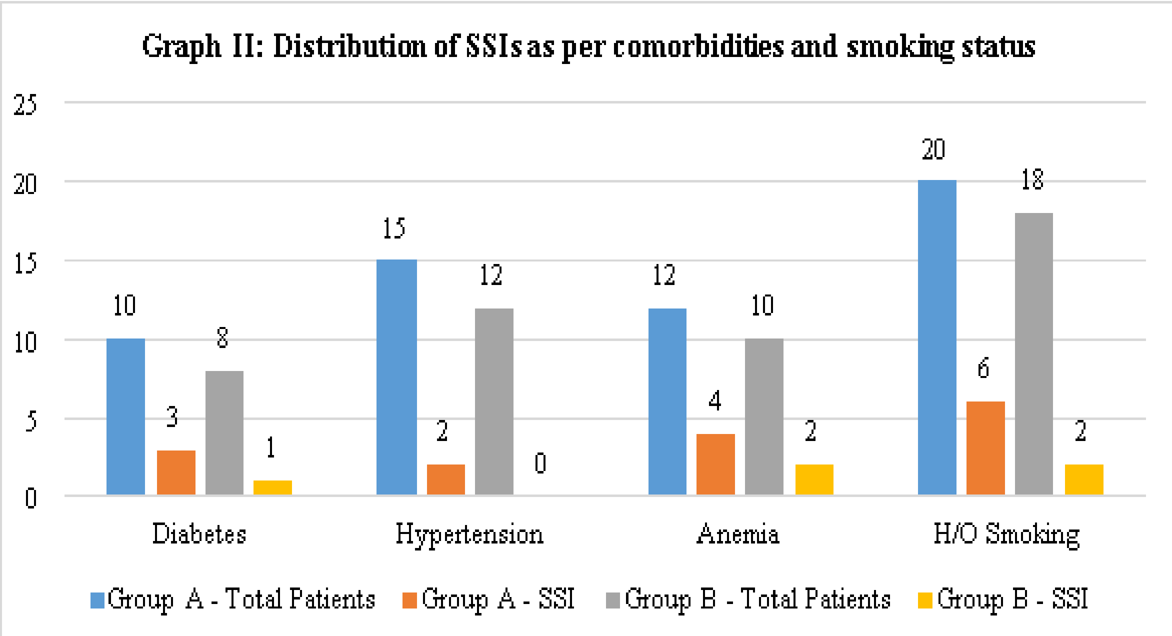

Table 2 and Graph II showing the focuses on comorbidities and smoking habits as factors influencing SSI rates. In the emergency group, diabetes (30.00%), anemia (33.33%), and smoking (30.00%) were significant contributors to SSIs. Hypertension had a lower SSI rate of 13.33%. In the planned group, anemia showed a notable SSI rate of 20.00%, followed by diabetes (12.50%). Smoking in the planned group also contributed to SSIs, albeit at a lower rate (11.11%).

Table 3: Distribution of Infections According to the Type of Surgery

Type of Surgery	Emergency Group - Total Patients	Emergency Group - SSI (N/%)	Planned Group - Total Patients	Planned Group - SSI (N/%)
Hernioplasty	5	0/0.00%	25	1/4.00%
Appendicectomy	20	4/20.00%	15	3/20.00%
Cholecystectomy	0	0/0.00%	10	2/20.00%
Peptic perforation	10	5/50.00%	0	0/0.00%
Intestinal perforation peritonitis	15	6/40.00%	0	0/0.00%
Blunt trauma abdomen	5	3/60.00%	0	0/0.00%
SAIO	5	2/40.00%	0	0/0.00%
MRM	0	0/0.00%	10	0/0.00%
Total	60	20/33.33%	60	6/10.00%

Table 3 show the highlights variations in SSI rates across different surgeries. In the emergency group, the highest SSI rates were observed for blunt trauma abdomen (60.00%), intestinal perforation peritonitis (40.00%), and peptic perforation (50.00%). In the planned group, appendicectomy and cholecystectomy had the highest SSI rates (20.00%). Hernioplasty had a minimal SSI rate (4.00%) in the planned group, while some procedures (e.g., MRM and SAIO) had no SSIs in either group.

Table 4: SSI Rates by Wound Classification

Group	Emergency - SSI/Total	Emergency - %	Planned - SSI/Total	Planned - %	P-value
Clean	0	0.00	1/30	3.33	-
Clean contaminated	2/22	9.09	3/25	12.00	-
Contaminated	3/12	25.00	0	0.00	-
Dirty	8/26	30.77	0	0.00	-
Total	13/60	21.67	4/60	6.67	0.104

Table 4 show the wound classification shows a significant difference in SSI rates. In the emergency group, SSIs were highest in dirty wounds (30.77%) and contaminated wounds (25.00%). In clean-contaminated wounds, the SSI rate was 9.09%, while clean wounds had no SSIs. In the planned group, clean-contaminated wounds showed an SSI rate of 12.00%, and clean wounds had a low SSI rate of 3.33%. No SSIs were observed in contaminated or dirty wounds in the planned group. The total SSI rate was higher in the emergency group (21.67%) compared to the planned group (6.67%), but the difference was not statistically significant ($p = 0.104$).

Table 5: SSI Rates by Surgery Duration

Group	<60 minutes - Cases	<60 minutes - SSI	<60 minutes - %	≥60 minutes - Cases	≥60 minutes - SSI	≥60 minutes - %	P-value
Emergency	20	3	15.00	40	10	25.00	0.087
Planned	28	0	0.00	32	5	15.63	0.319

Table 5 demonstrates that longer surgeries were associated with higher SSI rates. In the emergency group, surgeries lasting ≥60 minutes had an SSI rate of 25.00%, compared to 15.00% for surgeries under 60 minutes. In the planned group, the trend was similar, with a higher SSI rate for surgeries lasting ≥60 minutes (15.63%) compared to 0.00% for shorter surgeries. The p-values (0.087 for emergency and 0.319 for planned) indicate no statistical significance.

Table 6: Organisms and Symptoms

Category	Emergency Group - N (%)	Planned Group - N (%)
Escherichia coli	10 (47.62%)	2 (20.00%)
Staphylococcus aureus	8 (38.09%)	5 (50.00%)
Pseudomonas	3 (14.29%)	1 (10.00%)
Citrobacter	0 (0.00%)	2 (20.00%)
Total	21(100%)	10(100%)
Tachycardia	20 (33.33%)	5 (8.33%)
Fever	15 (25.00%)	3 (5.00%)
Pain	12 (20.00%)	2 (3.33%)
Redness/Edema	10 (16.67%)	1 (1.67%)
Swelling	8 (13.33%)	2 (3.33%)
Discharge	30 (50.00%)	8 (13.33%)

Table 6 show that the most common organisms identified in SSIs were Escherichia coli (47.62% in the emergency group) and Staphylococcus aureus (50.00% in the planned group). Pseudomonas (14.29%) and Citrobacter (20.00%) were less frequently observed.

In terms of symptoms, discharge (50.00% in emergency, 13.33% in planned), tachycardia (33.33% in emergency, 8.33% in planned), and fever (25.00% in emergency, 5.00% in planned) were the most common clinical presentations.

Table 7: Antibiotic Sensitivity

Antibiotic	Escherichia coli	Staphylococcus aureus	Pseudomonas	Citrobacter
Amikacin	8	5	0	0
Metronidazole	6	2	0	0
Azithromycin	2	6	0	0
Linezolid	0	4	0	0
Ceftriaxone	5	0	0	1
Meropenem	4	0	0	2
Imepenem	0	0	2	0
Moxifloxacin	0	0	3	0
Tobramycin	0	0	1	0
Ciprofloxacin	1	2	0	0
Tetracycline	0	3	0	0

Table 7 show the highlights the effectiveness of antibiotics against various organisms. Amikacin was the most effective antibiotic for Escherichia coli and Staphylococcus aureus, with sensitivity rates of 8 and 5, respectively. Metronidazole also showed high sensitivity for Escherichia coli (6). For Staphylococcus aureus, Azithromycin and Linezolid were effective, with sensitivities of 6 and 4, respectively. Moxifloxacin was highly effective against Pseudomonas (3), while Meropenem was effective against Citrobacter (2).

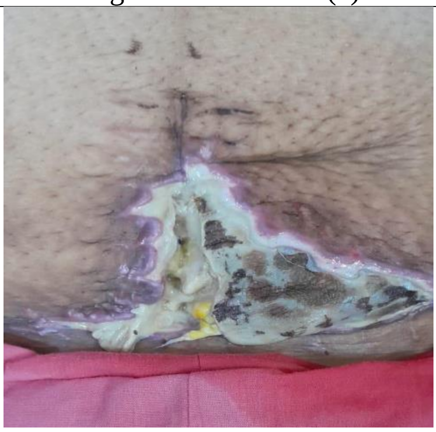

Figure 1: Surgical site wound infection in a patient with a known case of diabetes mellitus with a surgery done, i.e., hysterectomy for fibroid uterus and mesh hernioplasty for incisional hernia on a longitudinal scar of previous surgery.

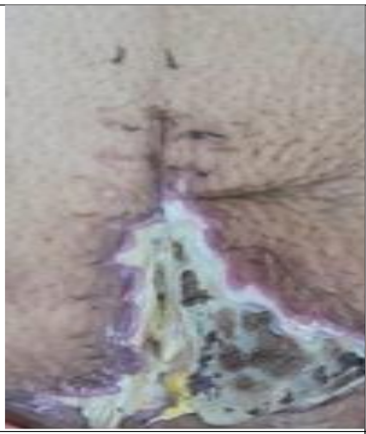

Figure 2: After 15 days of dressing and higher antibiotic coverage.

Figure 3: After 1 and a half months of dressing and proper antibiotic coverage.

Figure 4: After 2 and a half months of dressing and antibiotic coverage.

Figure 5: After the appearance of healthy granulation tissue, secondary suturing was done.

DISCUSSION

Surgical site infections (SSIs) remain a persistent challenge in emergency and planned abdominal surgeries, with notable differences in incidence rates, risk factors, and microbial profiles. Surgical site infections (SSIs) remain a major concern across all surgical specialties in hospital settings, despite advancements in aseptic techniques, antimicrobial therapies, sterilization processes, and surgical procedures. These infections contribute significantly to increased costs, morbidity, and mortality associated with surgical interventions. The presence of a wound infection can nearly double the cost of hospitalization for any given procedure. Beyond escalating hospital expenses, SSIs can lead to the development of antimicrobial resistance in patients, which may subsequently spread within the community and impact primary healthcare systems.[8] This study aims to evaluate the incidence of SSIs in our setting, identify the bacterial pathogens responsible, analyze their patterns of antibiotic resistance, and explore their association with various risk factors. In this study, SSIs were significantly more frequent in the emergency group (30.00%) than in the planned group (6.67%). The highest SSI rate in the emergency group was among patients aged 31–45 years and those aged ≥60 years (40.00%). Similar trends have been reported in studies by Kulkarni et al. (2018), where the SSI rate was significantly higher in older patients undergoing emergency procedures, likely due to compromised immunity and delayed interventions.[9] Conversely, the planned group exhibited lower SSI rates across all age groups, consistent with Singh et al. (2019), where the controlled environment and preoperative optimization contributed to reduced infection risks.[10] Gender-specific data revealed higher SSI rates in males (31.11% in emergency, 2.50% in planned) compared to females (26.67% in emergency, 15.00% in planned). This aligns with Rajput et al. (2020), who reported higher infection rates in males due to increased wound contamination from occupational and lifestyle factors.[11] Patients with diabetes, anemia, and smoking history were at greater risk of SSIs in this study. Diabetes showed a 30.00% SSI rate in the emergency group and 12.50% in the planned group, comparable to findings by Gupta et al. (2021), where hyperglycemia delayed wound healing and increased infection susceptibility.[12] Anemia was another significant factor, with SSI rates of 33.33% in the emergency group and 20.00% in the planned group. Smoking was associated with SSIs in both groups, with higher rates in the emergency group (30.00%), similar to studies by Choudhary et al. (2020), which linked smoking to impaired wound healing and compromised oxygenation.[13] Emergency surgeries involving contaminated and dirty wounds demonstrated significantly higher SSI rates. Procedures such as intestinal perforation peritonitis (40.00%) and peptic perforation (50.00%) had the highest infection risks, consistent with findings by Jain et al. (2022). In contrast, planned surgeries like hernioplasty and appendicectomy had lower SSI rates (4.00% and 20.00%, respectively), reflecting the benefits of preoperative preparation and elective scheduling.[14] The study highlights the correlation between wound contamination levels and SSI rates. Emergency surgeries with dirty and contaminated wounds showed SSI rates of 30.77% and 25.00%, respectively. These findings are in agreement with Ahmed et al. (2021), where similar patterns were observed. Clean and clean-contaminated wounds in planned surgeries had much lower SSI rates (3.33% and 12.00%, respectively), reaffirming the importance of asepsis.[15] Longer surgery durations were associated with higher SSIs in both groups. Emergency surgeries lasting ≥60 minutes had a 25.00% SSI rate, while shorter surgeries had 15.00%. Planned surgeries followed a similar pattern, with longer procedures showing higher SSI rates (15.63%). This aligns with Nandi et al. (2018), who emphasized the role of prolonged exposure and tissue manipulation in increasing infection risks.[16] Escherichia coli (47.62%) and Staphylococcus aureus (38.09%) were the predominant organisms in the emergency group, while Staphylococcus aureus (50.00%) was most common in the planned group. Similar trends were observed in Singh et al. (2020), where gram-negative organisms dominated in emergency cases due to fecal contamination.17 The antibiotic sensitivity profile revealed high effectiveness of Amikacin and Metronidazole against Escherichia coli and Staphylococcus aureus, consistent with Kumar et al. (2019).[18] Moxifloxacin and Meropenem showed good activity against Pseudomonas and Citrobacter, respectively. However, rising resistance to commonly used antibiotics was noted, mirroring findings by Patel et al. (2021).[19]

LIMITATIONS OF THE STUDY: The shortcoming of the study is small sample size and the study conducted at single centre.

CONCLUSION

The present study highlights the significantly higher incidence of surgical site infections (SSIs) in emergency abdominal surgeries (30.00%) compared to planned procedures (6.67%), with key risk factors including diabetes, anemia, smoking, and prolonged surgery duration. Dirty and contaminated wounds in emergency settings were associated with the highest SSI rates, while Escherichia coli and Staphylococcus aureus were the predominant pathogens. Antibiotics like Amikacin and Metronidazole demonstrated high efficacy, emphasizing the importance of targeted antimicrobial therapy. Enhanced preoperative optimization, strict aseptic techniques, and tailored antibiotic regimens are crucial to reducing SSI rates, particularly in high-risk emergency cases.

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