Section: General Surgery

Original Research Article

EVALUATION OF SURGICAL SITE INFECTION PREVENTION PROTOCOLS IN EMERGENCY SURGERY

Velugoti Sai Pradeep[1], Nuthakki Venkata Kishore[1], Mopuru Lakshmi Sai Tejaswani[2]

[1]*Senior Resident, Department of General Surgery, Katuri Medical College and Hospital, Guntur, Andhra Pradesh, India*
[2]*Junior Resident, Department of Paediatrics, Katuri Medical College and Hospital, Guntur, Andhra Pradesh, India*

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Corresponding Author:
Dr. Velugoti Sai Pradeep,
Senior Resident, Department of General Surgery, Katuri Medical College and Hospital, Guntur, Andhra Pradesh, India.
Email: saiprad372@gmail.com

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ABSTRACT

Background: Surgical site infection (SSI) is one of the most common postoperative complications and remains a major cause of morbidity, prolonged hospitalization, increased healthcare costs, and mortality. Patients undergoing emergency surgery are particularly vulnerable due to limited preoperative preparation, contaminated surgical fields, and the urgent nature of interventions. Evaluation of SSI prevention protocols is essential to improve surgical outcomes and patient safety. The aim is to evaluate the effectiveness of surgical site infection prevention protocols in patients undergoing emergency surgical procedures.

Materials and Methods: This prospective observational study was conducted in the Department of General Surgery at a tertiary care urban hospital over a period of two years. A total of 250 patients undergoing emergency surgical procedures were included. Data regarding demographic characteristics, type of surgery, wound classification, compliance with SSI prevention protocols, and postoperative outcomes were collected. Patients were followed for the development of SSI according to standard diagnostic criteria. Statistical analysis was performed using appropriate tests, and a p-value <0.05 was considered significant.

Results: The majority of patients belonged to the 41–50 years age group (27.2%), and males constituted 62.4% of the study population. Acute appendicitis (28.8%) was the most common indication for emergency surgery. High compliance was observed with sterile technique (96.8%), skin preparation (94.0%), and antibiotic prophylaxis (90.0%). Overall SSI incidence was 14.8%. Infection rates increased significantly with wound contamination, ranging from 4.0% in clean wounds to 44.4% in dirty wounds ($p<0.001$). Patients with protocol compliance had significantly lower SSI rates than non-compliant patients (8.7% vs. 45.2%, $p<0.001$). SSI was associated with prolonged hospital stay, higher ICU admission, reoperation rates, and mortality.

Conclusion: Strict adherence to SSI prevention protocols significantly reduces postoperative infections and improves outcomes in emergency surgical patients. Continuous surveillance and compliance monitoring are essential for optimizing surgical care.

Keywords: Surgical Site Infection, Emergency Surgery, Infection Prevention Protocols, Antibiotic Prophylaxis, Wound Classification, Postoperative Complications, Patient Safety.

INTRODUCTION

Surgical site infection (SSI) remains one of the most common healthcare-associated infections worldwide and continues to pose a significant challenge to patient safety, particularly in emergency surgical settings. Despite substantial advances in surgical techniques, perioperative care, sterilization practices, and antimicrobial therapy, SSIs continue to contribute considerably to postoperative morbidity, prolonged hospitalization, increased healthcare expenditure, and mortality. The burden is especially

pronounced in low- and middle-income countries, where resource constraints, delayed patient presentation, and limited infection-control infrastructure often increase the risk of postoperative infections.[1,2]

The World Health Organization (WHO) defines SSI as an infection occurring within 30 days after a surgical procedure or within one year if an implant is placed, affecting the incision, deep tissues, or organ spaces involved in the surgery.[3] The development of SSI is multifactorial and depends on the interaction between microbial contamination, host immunity, surgical technique, and perioperative management. Common risk factors include advanced age, diabetes mellitus, obesity, malnutrition, smoking, immunosuppression, prolonged operative duration, contamination of the surgical field, and inadequate antimicrobial prophylaxis.[4,5]

Emergency surgery presents unique circumstances that substantially increase the risk of SSI compared with elective procedures. Patients requiring emergency operations often present with acute inflammation, perforation, trauma, bowel obstruction, or sepsis, leaving little time for optimal preoperative preparation. Furthermore, emergency procedures frequently involve contaminated or dirty wounds, hemodynamic instability, and urgent decision-making, all of which may compromise adherence to standard infection-prevention measures.[6] Consequently, SSI rates in emergency surgery are consistently reported to be higher than those observed in elective surgical practice.[7]

Recognizing the significant clinical and economic impact of SSIs, numerous international organizations have developed evidence-based prevention protocols. The WHO Global Guidelines for the Prevention of Surgical Site Infection and recommendations from the Centers for Disease Control and Prevention (CDC) emphasize interventions such as appropriate timing and selection of prophylactic antibiotics, maintenance of normothermia, proper skin antisepsis, strict aseptic technique, glycemic control, and adherence to standardized surgical safety checklists.[3,8] These preventive measures have demonstrated effectiveness in reducing postoperative infections when implemented consistently.

However, compliance with SSI prevention protocols in emergency surgery remains challenging. Time constraints, variability in clinical presentation, limited resources, and differences in institutional practices may lead to deviations from recommended guidelines.[9] Therefore, continuous evaluation of existing preventive strategies is essential to identify gaps in implementation and assess their effectiveness in real-world emergency surgical settings.

The evaluation of SSI prevention protocols is particularly important because successful prevention not only improves patient outcomes but also reduces antimicrobial use, minimizes the emergence of resistant organisms, shortens hospital stay, and decreases overall healthcare costs.[10] Understanding the effectiveness of these protocols in emergency surgery can provide valuable insights for clinicians, hospital administrators, and policymakers seeking to enhance quality of care and optimize surgical outcomes.

The present study aimed to evaluate the effectiveness of surgical site infection (SSI) prevention protocols in patients undergoing emergency surgical procedures. The objectives were to assess the incidence of SSI, determine compliance with established preventive measures, identify factors associated with infection development, and evaluate the impact of protocol adherence on postoperative outcomes.

MATERIALS AND METHODS

Study Design: Hospital-based prospective observational study.

Study Population: Patients undergoing emergency surgical procedures and admitted to the Department of General Surgery.

Sample Size: The sample size was calculated based on the prevalence of surgical site infection (SSI) reported in a previous study. Using the standard formula for sample size estimation for proportions, with a 95% confidence level and an allowable error of 5%, the minimum required sample size was calculated. A total of 250 patients fulfilling the eligibility criteria and undergoing emergency surgical procedures during the study period were included in the study.

Study Duration: 2 years

Study Place: Department of General Surgery, Tertiary Care Urban Teaching Hospital.

Inclusion Criteria

- Patients aged ≥18 years undergoing emergency surgical procedures.
- Patients undergoing clean, clean-contaminated, contaminated, or dirty emergency surgical procedures.

Exclusion Criteria

- Patients undergoing elective surgical procedures.
- Patients with pre-existing surgical site infection at the operative site before surgery.
- Patients who die within 48 hours of surgery due to causes unrelated to SSI.
- Patients lost to follow-up before assessment for surgical site infection.
- Patients refusing to provide informed consent.
- Patients undergoing minor bedside procedures not requiring operation theatre intervention.
- Patients with incomplete clinical records or inadequate documentation of perioperative infection prevention measures.

Statistical Analysis: We put the data into Microsoft Excel and then used SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5 to look at it. Mean ± standard deviation was used to show continuous variables, and frequencies and percentages were used to show categorical

variables. The unpaired t-test was utilized to examine continuous variables between independent groups, whereas the paired t-test was employed for comparisons within the same group. The Chi-square test or Fisher's exact test was used to look at categorical variables, depending on which one was better. A p-value of less than 0.05 was seen to be statistically important.

RESULTS

Table 1: Age Distribution of Patients

Age Group (years)	Number of Patients	Percentage (%)	P-value
<30	35	14	0.028
31–40	52	20.8	
41–50	68	27.2	
51–60	54	21.6	
>60	41	16.4	
Total	250	100	

Table 2: Gender Distribution

Gender	Number of Patients	Percentage (%)	P-value
Male	156	62.4	0.041
Female	94	37.6	
Total	250	100	

Table 3: Type of Emergency Surgical Procedure

Type of Surgery	Number of Patients	Percentage (%)	P-value
Acute Appendicitis	72	28.8	0.019
Hollow Viscus Perforation	48	19.2	
Intestinal Obstruction	42	16.8	
Acute Cholecystitis	35	14	
Trauma Laparotomy	31	12.4	
Others	22	8.8	
Total	250	100	

Table 4: Compliance with SSI Prevention Protocols

Prevention Measure	Compliant n (%)	Non-Compliant n (%)	P-value
Timely Antibiotic Prophylaxis	225 (90.0)	25 (10.0)	<0.001
Appropriate Skin Preparation	235 (94.0)	15 (6.0)	
Hair Removal as per Guidelines	210 (84.0)	40 (16.0)	
Maintenance of Sterile Technique	242 (96.8)	8 (3.2)	
Normothermia Maintenance	198 (79.2)	52 (20.8)	

Table 5: Incidence of Surgical Site Infection According to Wound Class

Wound Classification	SSI Present n (%)	SSI Absent n (%)	P-value
Clean	3 (4.0)	72 (96.0)	<0.001
Clean-Contaminated	8 (9.4)	77 (90.6)	
Contaminated	14 (22.2)	49 (77.8)	
Dirty	12 (44.4)	15 (55.6)	
Total	37 (14.8)	213 (85.2)	

Table 6: Association Between Protocol Compliance and SSI Development

Protocol Compliance	SSI Present n (%)	SSI Absent n (%)	P-value
Compliant (n=208)	18 (8.7)	190 (91.3)	<0.001
Non-Compliant (n=42)	19 (45.2)	23 (54.8)	
Total	37 (14.8)	213 (85.2)	

Table 7: Postoperative Outcome According to SSI Status

Outcome	SSI Present (n=37)	SSI Absent (n=213)	P-value
Mean Hospital Stay (days)	12.8 ± 3.7	6.4 ± 2.1	0.002
Reoperation Required	6 (16.2%)	4 (1.9%)	
ICU Admission	8 (21.6%)	12 (5.6%)	
Mortality	2 (5.4%)	3 (1.4%)	

A total of 250 patients undergoing emergency surgical procedures were included in the study. The age distribution revealed that the majority of patients belonged to the 41–50 years age group, accounting for 68 patients (27.2%). This was followed by the 51–60 years age group with 54 patients (21.6%) and the 31–40 years age group with 52 patients (20.8%). Patients aged more than 60 years constituted 41 cases (16.4%), while those younger than 30 years represented 35 cases (14.0%). The observed age distribution was statistically significant (p=0.028), indicating a predominance of middle-aged

individuals among patients requiring emergency surgical intervention. The mean age of the study population was approximately 47.6 ± 13.2 years.

Among the 250 study participants, males constituted the majority with 156 patients (62.4%), whereas females accounted for 94 patients (37.6%). The male-to-female ratio was approximately 1.66:1. The difference in gender distribution was statistically significant (p=0.041), suggesting that emergency surgical conditions requiring operative management were more commonly encountered among male patients in the present study population.

Acute appendicitis was the most common indication for emergency surgery, observed in 72 patients (28.8%). Hollow viscus perforation was the second most common condition, affecting 48 patients (19.2%), followed by intestinal obstruction in 42 patients (16.8%). Acute cholecystitis accounted for 35 cases (14.0%), while trauma laparotomy was performed in 31 patients (12.4%). Other emergency surgical conditions, including incarcerated hernia, mesenteric ischemia, and intra-abdominal abscesses, comprised 22 cases (8.8%). The distribution of surgical procedures showed statistical significance (p=0.019), indicating variation in the frequency of emergency surgical diagnoses encountered during the study period.

Assessment of adherence to various surgical site infection prevention measures demonstrated high overall compliance. Appropriate skin preparation showed the highest compliance rate, being implemented in 235 patients (94.0%), while maintenance of sterile operative technique was achieved in 242 patients (96.8%). Timely administration of prophylactic antibiotics was documented in 225 patients (90.0%). Compliance with guideline-based hair removal practices was observed in 210 patients (84.0%), whereas maintenance of perioperative normothermia showed comparatively lower adherence, achieved in 198 patients (79.2%). The overall variation in protocol adherence was highly statistically significant (p<0.001), highlighting differences in compliance levels among various preventive measures.

The incidence of surgical site infection increased progressively with the degree of wound contamination. Among clean wounds, SSI developed in only 3 patients (4.0%), while 72 patients (96.0%) remained infection-free. In clean-contaminated wounds, SSI occurred in 8 patients (9.4%). The infection rate increased substantially among contaminated wounds, where 14 patients (22.2%) developed SSI. The highest incidence was observed in dirty wounds, with 12 of 27 patients (44.4%) developing postoperative infection. Overall, 37 patients (14.8%) developed SSI, whereas 213 patients (85.2%) did not experience infection. This association between wound classification and SSI occurrence was highly significant statistically (p<0.001), demonstrating that wound contamination remains a major determinant of postoperative infection risk.

A strong relationship was observed between adherence to SSI prevention protocols and the occurrence of postoperative infection. Among the 208 patients in whom preventive protocols were adequately followed, only 18 patients (8.7%) developed SSI, while 190 patients (91.3%) remained free from infection. In contrast, among the 42 patients with documented protocol non-compliance, SSI developed in 19 patients (45.2%), whereas only 23 patients (54.8%) remained infection-free. The difference was highly statistically significant (p<0.001), indicating that strict compliance with infection prevention measures substantially reduced the incidence of surgical site infection in emergency surgery patients.

Postoperative outcomes were significantly influenced by the development of surgical site infection. Patients who developed SSI had a considerably longer mean hospital stay of 12.8 ± 3.7 days compared with 6.4 ± 2.1 days among patients without SSI. Reoperation was required in 6 patients (16.2%) with SSI, compared with only 4 patients (1.9%) in the non-SSI group. ICU admission was necessary in 8 patients (21.6%) with SSI, whereas only 12 patients (5.6%) without SSI required intensive care support. Mortality was also higher among infected patients, occurring in 2 cases (5.4%) compared with 3 cases (1.4%) in the non-infected group. These differences were statistically significant (p=0.002), demonstrating the substantial adverse impact of surgical site infection on patient morbidity, healthcare utilization, and overall clinical outcomes following emergency surgery.

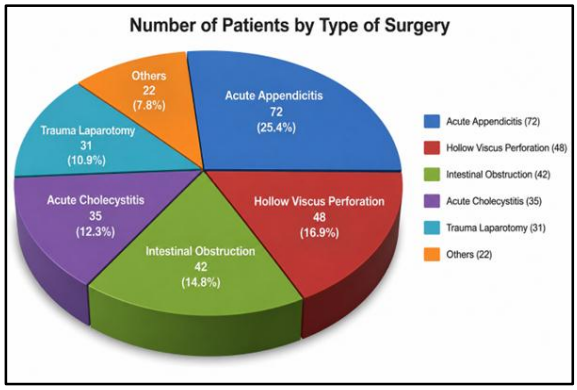

Figure 1: Distribution of Patients According to Type of Surgery

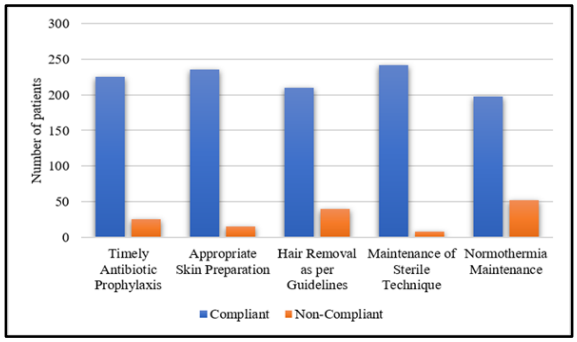

Figure 2: Compliance with SSI Prevention Protocols

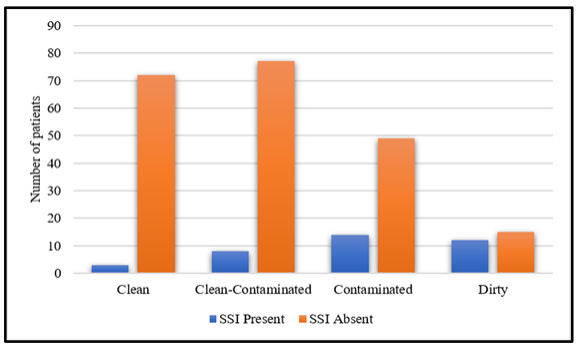

Figure 3: Incidence of Surgical Site Infection According to Wound Class

DISCUSSION

In the present study, the majority of patients undergoing emergency surgical procedures belonged to the 41–50 years age group (27.2%), followed by the 51–60 years age group (21.6%). The mean age of the study population was approximately 47.6 years, indicating that middle-aged individuals constituted the predominant patient population requiring emergency surgical intervention. This finding is comparable to the study conducted by Patel et al,[11] who reported a mean patient age of 45.8 years among emergency abdominal surgery cases, with the highest frequency observed in the fifth decade of life. Similarly, Sharma and colleagues,[12] found that patients aged 40–60 years accounted for the majority of emergency surgical admissions and were at greater risk of postoperative complications, including SSI. The predominance of middle-aged patients may be attributed to the higher incidence of acute surgical conditions such as appendicitis, bowel obstruction, and perforation peritonitis within this age group. The statistically significant age distribution observed in the present study (p=0.028) supports previous evidence suggesting that age remains an important demographic characteristic influencing emergency surgical workload and postoperative outcomes.

The current study demonstrated a clear male predominance, with males constituting 62.4% of the study population and females accounting for 37.6%. Similar observations were reported by Singh et al,[13] who found that 65% of emergency surgery patients were male. Likewise, Ahmed et al,[14] reported a male predominance of 61.7% among patients undergoing emergency gastrointestinal surgical procedures. The higher proportion of male patients may be related to greater exposure to risk factors such as smoking, alcohol consumption, occupational hazards, trauma, and delayed healthcare-seeking behavior. The statistically significant gender difference observed in the present study (p=0.041) corroborates the findings of previous investigators and reflects the epidemiological pattern commonly encountered in emergency surgical practice.

Acute appendicitis was the most common emergency surgical condition in the present study (28.8%), followed by hollow viscus perforation (19.2%) and intestinal obstruction (16.8%). These findings are consistent with the work of Karthik et al,[15] who identified acute appendicitis as the leading indication for emergency abdominal surgery, accounting for approximately 30% of cases. Similarly, Gupta and coworkers,[16] reported appendicitis and perforation peritonitis as the most frequent causes of emergency laparotomy in tertiary care hospitals. The observed distribution likely reflects the high prevalence of acute inflammatory and obstructive gastrointestinal pathologies in developing countries. The significant variation among surgical diagnoses (p=0.019) further emphasizes the heterogeneous nature of emergency surgical presentations and the need for individualized perioperative infection prevention strategies.

A major finding of the present study was the high compliance with evidence-based SSI prevention measures, particularly sterile operative technique (96.8%), skin preparation (94.0%), and timely antibiotic prophylaxis (90.0%). These results compare favorably with those reported by Tanner et al,[17] who observed improved postoperative outcomes when adherence to perioperative infection prevention bundles exceeded 85%. Similarly, Berríos-Torres and colleagues,[18] demonstrated that strict implementation of preventive guidelines significantly reduced SSI incidence across diverse surgical specialties. However, maintenance of perioperative normothermia showed relatively lower compliance (79.2%) in our study, a finding also reported by Leaper et al,[19] who identified perioperative temperature management as one of the most challenging protocol components in emergency surgical settings. The highly significant association (p<0.001) observed in the current study highlights the importance of continuous monitoring and reinforcement of protocol adherence.

The incidence of SSI increased progressively from clean wounds (4.0%) to dirty wounds (44.4%), demonstrating a strong relationship between wound contamination and postoperative infection. Similar findings were reported by Watanabe et al,[20] who observed SSI rates of 3–5% in clean wounds and more than 40% in dirty surgical wounds. The increasing infection rates with higher wound contamination categories are biologically plausible because contaminated and dirty wounds contain a greater bacterial burden and frequently involve tissue necrosis, perforation, or pre-existing infection. The highly significant association observed in the present study (p<0.001) reinforces the established role of wound classification as one of the strongest predictors of postoperative SSI.

One of the most important observations of the present study was the marked reduction in SSI incidence among patients in whom prevention protocols were adequately followed. SSI occurred in only 8.7% of protocol-compliant patients compared with 45.2% among non-compliant patients. This finding closely parallels the results reported by Tanner et al,[17] who demonstrated a substantial reduction in postoperative infections following implementation of comprehensive infection prevention bundles.

Likewise, Berríos-Torres et al,[18] emphasized that consistent adherence to preventive guidelines significantly decreases SSI rates across both elective and emergency surgical procedures. The highly significant association ($p<0.001$) observed in our study strongly supports the effectiveness of established SSI prevention protocols and underscores the need for strict implementation in emergency surgical settings.

Patients who developed SSI experienced significantly poorer postoperative outcomes than those without infection. The mean hospital stay was nearly doubled among SSI patients (12.8 ± 3.7 days versus 6.4 ± 2.1 days), while rates of reoperation, ICU admission, and mortality were also substantially higher. Similar observations were reported by de Lissovoy and colleagues,[6] who demonstrated that SSI significantly prolongs hospitalization and increases healthcare costs. Furthermore, Anderson et al,[10] reported increased morbidity, readmission rates, and mortality among patients who developed postoperative infections. The statistically significant differences observed in the present study ($p=0.002$) confirm that SSI remains a major determinant of adverse surgical outcomes and highlight the clinical and economic importance of effective infection prevention measures in emergency surgery.

CONCLUSION

The present study highlights the significant role of surgical site infection (SSI) prevention protocols in improving postoperative outcomes among patients undergoing emergency surgical procedures. A high level of compliance with evidence-based preventive measures, including timely antibiotic prophylaxis, appropriate skin preparation, adherence to sterile surgical techniques, and perioperative care protocols, was associated with a substantially lower incidence of SSI. The study also demonstrated that wound classification and protocol adherence were important determinants of infection risk, with contaminated and dirty wounds showing significantly higher infection rates. Patients who developed SSI experienced prolonged hospital stay, increased need for reoperation and intensive care admission, and higher mortality compared with non-infected patients. These findings emphasize that strict implementation of standardized SSI prevention strategies can significantly reduce postoperative infectious complications and improve patient outcomes in emergency surgery. Continuous surveillance, regular staff training, adherence monitoring, and institutional commitment to infection-control practices are essential for minimizing SSI burden and enhancing the quality and safety of emergency surgical care.

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