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Risk Factors And Prevention Strategies For Surgical Site Infections In Emergency Abdominal Surgery

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ABSTRACT

Background: Surgical site infections (SSIs) represent a significant burden in emergency abdominal surgery, with incidence rates substantially higher than in elective procedures. This study aimed to determine the incidence of SSIs following emergency abdominal surgery, identify modifiable risk factors, and evaluate the effectiveness of current prevention strategies in our institutional setting.

Methods: This prospective observational cohort study was conducted from January 2023 to June 2024 at KAHER's JGMM Medical College, Hubballi. Adult patients (≥18 years) undergoing emergency abdominal surgery within 24 hours of admission were included. Patients were monitored for SSI development using CDC criteria during hospitalization and at follow-up visits (1 week, 2 weeks, and 30 days postoperatively). Demographic data, preoperative parameters, intraoperative details, and postoperative outcomes were recorded. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors.

Results: Among 252 patients enrolled, 41 (16.3%) developed SSIs, with 27 (65.9%) being superficial, 11 (26.8%) deep, and 3 (7.3%) organ/space infections. Open surgical approach (OR=4.78, 95% CI: 2.16-10.59, p<0.001), prolonged operative time >120 minutes (OR=3.21, 95% CI: 1.48-6.97, p=0.003), contaminated/dirty wounds (OR=2.87, 95% CI: 1.31-6.28, p=0.008), and preoperative albumin <3.0 g/dL (OR=2.63, 95% CI: 1.22-5.67, p=0.014) were identified as independent risk factors. Escherichia coli was the most commonly isolated pathogen (58.3%), with 76.4% showing resistance to the prophylactic antibiotics administered. The mean length of hospital stay was significantly longer in patients with SSI compared to those without (14.7±3.2 vs. 7.3±1.8 days, p<0.001).

Conclusion: The incidence of SSI following emergency abdominal surgery remains high, with identifiable modifiable risk factors. Implementation of targeted prevention strategies addressing surgical technique, operative duration, and preoperative optimization may reduce SSI rates and improve patient outcomes.

Keywords: *Surgical site infection; emergency abdominal surgery; risk factors; prevention strategies; antimicrobial resistance*

1. INTRODUCTION

Surgical site infections (SSIs) represent one of the most common healthcare-associated infections worldwide, significantly contributing to postoperative morbidity, mortality, and healthcare costs. The global burden of SSIs is substantial, with the World Health Organization reporting that in low- and middle-income countries, 11% of patients who undergo surgery are infected in the process, while in Africa, up to 20% of women undergoing caesarean sections contract wound infections[1]. In the United States alone, SSIs contribute to patients spending more than 400,000 extra days in hospital at an additional cost of $900 million per year[2]. The Centers for Disease Control and Prevention defines SSIs as infections occurring at or near the surgical incision within 30 to 90 days of the procedure, depending on the type of procedure performed[3].

Emergency abdominal surgery presents unique challenges in preventing SSIs compared to elective procedures. The incidence of SSI after emergency abdominal surgery (EAS) is significantly higher than in elective surgery, with rates ranging from 6.7% to 35% depending on the type of procedure and patient population[4]. Multiple factors contribute to this increased risk, including the urgent nature of the surgery which limits preoperative optimization, higher likelihood of contaminated or dirty wounds, compromised patient physiology, and pre-existing infections. Emergency laparotomies, often performed under suboptimal conditions with inadequate patient preparation, carry a particularly high risk due to intraoperative contamination and the critical condition of patients requiring urgent surgical intervention.

The pathophysiology of SSI involves a complex interplay between microbial factors, host defenses, and environmental conditions. In emergency abdominal surgery, the risk is amplified by the frequent presence of intra-abdominal contamination, tissue ischemia, and compromised host immunity. Bacterial contamination of the surgical site is almost inevitable in emergency laparotomies for conditions such as hollow viscus perforation, intestinal obstruction with gangrenous bowel, or traumatic injuries with spillage of gastrointestinal contents. The resultant inflammatory response and subsequent infection depend on the bacterial load, virulence of organisms, and the host's ability to mount an effective immune response.

Current literature demonstrates significant variability in SSI rates following emergency abdominal surgery across different healthcare settings and geographical regions. Recent prospective studies have shown SSI incidence rates ranging from 14.4% to 17.12% in emergency laparotomy patients, with higher rates observed in open surgical approaches compared to laparoscopic procedures[5]. The burden is particularly severe in resource-limited settings where infection control measures may be suboptimal and antimicrobial resistance patterns are unfavorable. Extended-spectrum β-lactamase-producing organisms have emerged as predominant pathogens, with studies showing that only 23% of cultured bacteria are sensitive to standard prophylactic antibiotics, highlighting the urgent need for updated prevention strategies[6].

Risk factors for SSI in emergency abdominal surgery can be categorized into patient-related, procedure-related, and environment-related factors. Patient-related factors include advanced age, malnutrition, obesity, diabetes mellitus, immunosuppression, and presence of comorbidities. Procedure-related factors encompass the degree of wound contamination, duration of surgery, surgical technique, intraoperative blood loss, and use of drains. Environmental factors include operating room conditions, infection control practices, and compliance with perioperative protocols. The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) has identified several high-risk factors for SSI, including prolonged operative time, wound classification, ASA score, and emergency procedures[7].

Prevention strategies for SSI in emergency abdominal surgery should ideally address modifiable risk factors across the preoperative, intraoperative, and postoperative phases of care. Preoperative interventions include appropriate antibiotic prophylaxis, glycemic control, and correction of modifiable risk factors when time permits. Intraoperative measures involve adherence to surgical asepsis, minimizing tissue trauma, maintaining normothermia, and ensuring adequate oxygenation. Postoperative strategies include appropriate wound care, surveillance for early signs of infection, and judicious use of antibiotics. The World Health Organization and the Centers for Disease Control and Prevention have published comprehensive guidelines for SSI prevention, though many recommendations are based on evidence from elective surgery[8].

Despite advances in surgical techniques, antimicrobial prophylaxis, and infection control practices, significant gaps remain in our understanding of modifiable risk factors specific to emergency abdominal surgery. Current prevention guidelines are largely based on elective surgery data and may not adequately address the unique challenges of emergency procedures. There is limited evidence on the effectiveness of various intraoperative preventive measures in the emergency setting, optimal antimicrobial prophylaxis regimens considering local resistance patterns, and the role of newer technologies such as wound protectors and antibacterial sutures in this high-risk population.

The economic burden of SSIs extends beyond direct healthcare costs to include productivity losses, prolonged disability, and reduced quality of life. In resource-constrained settings, the impact is further magnified by limited access to advanced wound care, newer antimicrobial agents, and rehabilitative services. A systematic approach to SSI prevention not only improves patient outcomes but also reduces healthcare costs and resource utilization. Studies from high-income countries have demonstrated that implementation of comprehensive SSI prevention bundles can reduce infection rates by up to 40%, with significant cost savings[9].

In the context of antimicrobial stewardship, addressing the high SSI rates in emergency abdominal surgery has additional significance. The emergence of multidrug-resistant organisms has been partly attributed to inappropriate antimicrobial use, including prolonged postoperative antibiotic therapy in surgical patients. By identifying high-risk patients and implementing targeted prevention strategies, unnecessary antibiotic exposure can be reduced, contributing to broader efforts to combat antimicrobial resistance. The Global Alliance for Infections in Surgery has emphasized the importance of balancing effective infection prevention with judicious antimicrobial use[10].

The current study was designed to address these knowledge gaps by comprehensively evaluating the risk factors associated with SSIs in emergency abdominal surgery and assessing the effectiveness of current prevention strategies in our local context. By identifying modifiable risk factors and evaluating prevention measures specific to emergency procedures, this research aimed to contribute to developing evidence-based protocols tailored to the unique challenges of emergency abdominal surgery. The findings were expected to guide clinicians in implementing targeted interventions to reduce SSI rates, improve patient outcomes, and optimize resource utilization in emergency surgical care.

2. AIMS AND OBJECTIVES

The study aimed to determine the incidence of surgical site infections following emergency abdominal surgery in our institution and identify modifiable risk factors associated with increased SSI rates in emergency laparotomy patients. The investigation evaluated the effectiveness of current perioperative prevention strategies in reducing SSI incidence. Secondary objectives included analyzing the microbiological profile and antimicrobial resistance patterns of organisms causing SSI and assessing the correlation between preoperative patient factors (nutritional status, comorbidities) and SSI development. The research was designed to provide comprehensive data on SSI epidemiology specific to emergency abdominal surgery, which could inform the development of targeted prevention protocols and improve patient outcomes in this high-risk population.

3. MATERIALS AND METHODS

Study Design and Setting

A prospective observational cohort study was conducted at the Department of General Surgery, KAHER's Jagadguru Gangadhar Mahaswamigalu Moorusaviramath Medical College, Hubballi, from January 2023 to June 2024.

Sample Size Calculation

Based on the study by Alkaaki et al. (2019), which reported an SSI incidence of 16.3% in abdominal surgery patients, the sample size was calculated using the following formula:

$n = Z^2\alpha/2 \times p \times (1-p) / d^2$

Where:

- $Z\alpha/2 = 1.96$ (standard normal deviate at 95% confidence level, $\alpha=0.05$)
- $p = 0.163$ (expected proportion of SSI based on literature)
- $d = 0.05$ (absolute precision)

The calculated sample size was 210 patients. To account for potential dropouts, loss to follow-up, and technical failures, 20% additional subjects were included, resulting in a final target sample size of 252 patients.

Study Population

The study included adult patients (≥18 years) presenting to the emergency department with acute abdominal conditions requiring urgent surgical intervention, including perforated viscus, intestinal obstruction, abdominal trauma, and complicated appendicitis or cholecystitis. Patients were enrolled if they underwent emergency laparotomy within 24 hours of admission and were available for 30-day postoperative follow-up.

Exclusion criteria were patients with pre-existing active infections at sites other than the abdomen, immunocompromised patients (HIV positive, on immunosuppressive therapy, active malignancy on chemotherapy), patients undergoing relaparotomy within 30 days of previous surgery, patients with chronic wound healing disorders, pregnant women, patients who expired within 48 hours postoperatively, and patients lost to follow-up before 30 days.

Data Collection

Demographic data including age, sex, body mass index (BMI), and presence of comorbidities (diabetes mellitus, hypertension, chronic obstructive pulmonary disease, chronic kidney disease) were recorded at admission. Preoperative parameters assessed included hemoglobin, total protein, serum albumin, random blood glucose, total white blood cell count, and American Society of Anesthesiologists (ASA) physical status classification.

Intraoperative details documented were type of surgery (perforation repair, resection-anastomosis, adhesiolysis, others), surgical approach (open or laparoscopic), wound classification as per CDC criteria (clean-contaminated, contaminated, dirty), duration of surgery, estimated blood loss, use of wound protectors, type of suture material, and any intraoperative complications.

Postoperative monitoring for SSI was performed daily until discharge and during follow-up visits at 1 week, 2 weeks, and 30 days post-surgery. SSI was diagnosed based on CDC criteria: purulent drainage from the surgical site, organisms isolated from culture of fluid or tissue from the surgical site, signs and symptoms of infection (pain, tenderness, swelling, redness, or heat) and surgical site deliberately opened by surgeon, or diagnosis of SSI by the surgeon or attending physician. SSIs were classified as superficial incisional, deep incisional, or organ/space infections according to CDC definitions.

For suspected SSI cases, wound swab or tissue samples were collected for culture and antimicrobial sensitivity testing. The microbiological profile and resistance patterns were documented. Additional outcome measures included length of hospital stay, need for reoperation, and 30-day mortality.

Patient Management Protocol

All patients received standard emergency assessment and stabilization according to Advanced Trauma Life Support (ATLS) protocols. Preoperative blood investigations including complete blood count, renal function tests, liver function tests, and coagulation profile were performed. Antibiotic prophylaxis was administered as per institutional protocol, typically a third-generation cephalosporin with metronidazole, within 60 minutes before surgical incision.

Standard surgical techniques were employed, including proper skin preparation with chlorhexidine-alcohol solution, hair removal using clippers when necessary, maintenance of normothermia (core temperature >36°C), use of wound protectors when available, meticulous hemostasis, and appropriate fascial and skin closure techniques. Postoperative care included wound care, continuation of antibiotics based on intraoperative findings, and early mobilization.

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as frequencies and percentages for categorical variables and as mean ± standard deviation or median (interquartile range) for continuous variables, depending on data distribution. Normality of continuous data was assessed using the Shapiro-Wilk test.

Comparative analyses between patients with and without SSI were performed using Chi-square test or Fisher's exact test for categorical variables and Student's t-test or Mann-Whitney U test for continuous variables as appropriate. Risk factors for SSI were identified using univariate logistic regression, and variables with $p<0.1$ in univariate analysis were included in multivariate logistic regression to identify independent predictors. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. Kaplan-Meier analysis was used to estimate time to SSI development. Statistical significance was set at $p<0.05$ for all analyses.

4. RESULTS

Demographic and Clinical Characteristics

During the 18-month study period, 287 patients underwent emergency abdominal surgery. After applying exclusion criteria, 252 patients were included in the final analysis. The mean age of the study population was 43.8±15.7 years, with a male predominance (64.3%). The most common indications for emergency surgery were hollow viscus perforation (38.1%), acute intestinal obstruction (29.8%), acute appendicitis (19.0%), and abdominal trauma (13.1%). Table 1 presents the baseline demographic and clinical characteristics of the study population.

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	Total (n=252)	SSI Group (n=41)	Non-SSI Group (n=211)	p-value
Age (years)				
Mean ± SD	43.8 ± 15.7	47.6 ± 16.2	43.0 ± 15.5	0.092
Sex, n (%)				
Male	162 (64.3)	28 (68.3)	134 (63.5)	0.549
Female	90 (35.7)	13 (31.7)	77 (36.5)	
BMI (kg/m²)				

Mean ± SD	24.3 ± 4.1	25.8 ± 4.6	24.0 ± 3.9	0.012*
Comorbidities, n (%)				
Diabetes mellitus	57 (22.6)	16 (39.0)	41 (19.4)	0.006*

Characteristic	**Total (n=252)**	**SSI Group (n=41)**	**Non-SSI Group (n=211)**	**p-value**
Hypertension	64 (25.4)	12 (29.3)	52 (24.6)	0.527
COPD	31 (12.3)	8 (19.5)	23 (10.9)	0.123
Chronic kidney disease	17 (6.7)	4 (9.8)	13 (6.2)	0.396
Indication for surgery, n (%)				
Hollow viscus perforation	96 (38.1)	21 (51.2)	75 (35.5)	0.034*
Acute intestinal obstruction	75 (29.8)	11 (26.8)	64 (30.3)	
Acute appendicitis	48 (19.0)	4 (9.8)	44 (20.9)	
Abdominal trauma	33 (13.1)	5 (12.2)	28 (13.3)	
ASA grade, n (%)				
I	47 (18.7)	3 (7.3)	44 (20.9)	0.009*
II	98 (38.9)	12 (29.3)	86 (40.8)	
III	79 (31.3)	17 (41.5)	62 (29.4)	
IV	28 (11.1)	9 (21.9)	19 (9.0)	

*Statistically significant ($p<0.05$) ASA: American Society of Anesthesiologists, BMI: Body Mass Index, COPD: Chronic Obstructive Pulmonary Disease, SD: Standard Deviation, SSI: Surgical Site Infection

Incidence and Classification of SSI

The overall incidence of SSI was 16.3% (41/252). Of these, 27 (65.9%) were superficial incisional SSIs, 11 (26.8%) were deep incisional SSIs, and 3 (7.3%) were organ/space infections. The median time to SSI diagnosis was 7 days (IQR: 5-10 days), with 63.4% of infections diagnosed during the initial hospital stay and 36.6% identified during follow-up visits. The cumulative incidence of SSI over the 30-day follow-up period is illustrated in Table 2.

Table 2: Incidence and Classification of Surgical Site Infections

Variable	**n (%)**
Overall SSI incidence	41 (16.3)
SSI classification	
Superficial incisional	27 (65.9)
Deep incisional	11 (26.8)
Organ/space	3 (7.3)
Time to SSI diagnosis	
≤7 days post-surgery	22 (53.7)

8-14 days post-surgery	14 (34.1)
15-30 days post-surgery	5 (12.2)

Variable	**n (%)**
Diagnosis setting	
During hospital stay	26 (63.4)
During follow-up visits	15 (36.6)
Signs and symptoms	
Purulent discharge	31 (75.6)
Erythema and swelling	36 (87.8)
Fever	23 (56.1)
Wound dehiscence	16 (39.0)
Spontaneous wound drainage	27 (65.9)
Surgeon-initiated drainage	14 (34.1)

SSI: Surgical Site Infection

Preoperative and Intraoperative Factors

Analysis of preoperative laboratory parameters revealed significant differences between the SSI and non-SSI groups in terms of hemoglobin levels, serum albumin, and random blood glucose. Patients who developed SSI had lower mean hemoglobin (10.2±2.1 vs. 11.6±1.9 g/dL, p<0.001) and serum albumin levels (2.8±0.6 vs. 3.4±0.7 g/dL, p<0.001), and higher random blood glucose (156.3±42.7 vs. 127.4±37.9 mg/dL, p<0.001).

Regarding intraoperative factors, patients with SSI had significantly longer mean operative time (142.8±38.3 vs. 98.6±30.2 minutes, p<0.001) and higher estimated blood loss (321.7±143.2 vs. 217.5±108.9 mL, p<0.001). The incidence of SSI was significantly higher in open surgeries compared to laparoscopic procedures (21.7% vs. 5.3%, p<0.001) and in contaminated/dirty wounds compared to clean-contaminated wounds (25.6% vs. 9.4%, p<0.001). Table 3 presents the comparison of preoperative and intraoperative factors between the SSI and non-SSI groups.

Table 3: Preoperative and Intraoperative Factors Associated with Surgical Site Infection

Variable	**SSI Group (n=41)**	**Non-SSI Group (n=211)**	**p-value**
Preoperative laboratory parameters			
Hemoglobin (g/dL), mean ± SD	10.2 ± 2.1	11.6 ± 1.9	<0.001*
Total protein (g/dL), mean ± SD	5.9 ± 0.9	6.4 ± 0.8	0.002*
Serum albumin (g/dL), mean ± SD	2.8 ± 0.6	3.4 ± 0.7	<0.001*
Random blood glucose (mg/dL), mean ± SD	156.3 ± 42.7	127.4 ± 37.9	<0.001*
Total WBC count (/mm³), mean ± SD	14862 ± 4328	12786 ± 4015	0.005*
Timing of antibiotic prophylaxis, n (%)			
>60 minutes before incision	7 (17.1)	31 (14.7)	0.132
30-60 minutes before incision	27 (65.9)	159 (75.4)	

<30 minutes before incision	7 (17.1)	21 (10.0)	

Variable	**SSI Group (n=41)**	**Non-SSI Group (n=211)**	**p-value**
Surgical approach, n (%)			
Open	38 (92.7)	137 (64.9)	<0.001*
Laparoscopic	3 (7.3)	53 (25.1)	
Laparoscopic converted to open	0 (0.0)	21 (10.0)	
Wound classification, n (%)			
Clean-contaminated	12 (29.3)	116 (55.0)	<0.001*
Contaminated	17 (41.5)	68 (32.2)	
Dirty	12 (29.3)	27 (12.8)	
Operative time (minutes), mean ± SD	142.8 ± 38.3	98.6 ± 30.2	<0.001*
Estimated blood loss (mL), mean ± SD	321.7 ± 143.2	217.5 ± 108.9	<0.001*
Use of wound protector, n (%)	8 (19.5)	63 (29.9)	0.171
Use of antibacterial suture, n (%)	6 (14.6)	47 (22.3)	0.269
Intraoperative core temperature <36°C, n (%)	19 (46.3)	57 (27.0)	0.013*

*Statistically significant (p<0.05) SD: Standard Deviation, SSI: Surgical Site Infection, WBC: White Blood Cell

Risk Factors for SSI

Univariate logistic regression analysis identified several potential risk factors for SSI, including age >60 years, BMI >30 kg/m², diabetes mellitus, hollow viscus perforation, ASA grade ≥III, preoperative hemoglobin <10 g/dL, serum albumin <3.0 g/dL, random blood glucose >140 mg/dL, open surgical approach, contaminated/dirty wounds, operative time >120 minutes, estimated blood loss >250 mL, and intraoperative hypothermia.

In multivariate logistic regression analysis, four factors remained as independent predictors of SSI: open surgical approach (OR=4.78, 95% CI: 2.16-10.59, p<0.001), operative time >120 minutes (OR=3.21, 95% CI: 1.48-6.97, p=0.003), contaminated/dirty wounds (OR=2.87, 95% CI: 1.31-6.28, p=0.008), and preoperative serum albumin <3.0 g/dL (OR=2.63, 95% CI: 1.22-5.67, p=0.014). Table 4a presents the univariate analysis, and Table 4b shows the results of multivariate logistic regression.

Table 4a: Univariate Analysis of Risk Factors for Surgical Site Infection

Risk Factor	**Odds Ratio**	**95% CI**	**p-value**
Age >60 years	1.98	0.96-4.09	0.064
Male sex	1.23	0.61-2.50	0.562
BMI >30 kg/m²	2.76	1.21-6.30	0.016*
Diabetes mellitus	2.67	1.30-5.47	0.007*
Hypertension	1.27	0.61-2.63	0.527
COPD	1.98	0.82-4.77	0.129
Hollow viscus perforation	1.91	0.97-3.76	0.063

Risk Factor	Odds Ratio	95% CI	p-value
ASA grade ≥III	2.57	1.28-5.17	0.008*
Hemoglobin <10 g/dL	3.19	1.57-6.47	0.001*
Serum albumin <3.0 g/dL	4.01	1.97-8.17	<0.001*
Random blood glucose >140 mg/dL	2.73	1.36-5.47	0.005*
Total WBC count >12,000/mm³	1.87	0.92-3.79	0.084
Antibiotic prophylaxis <30 min before incision	1.86	0.73-4.74	0.192
Open surgical approach	6.67	2.92-15.23	<0.001*
Contaminated/dirty wounds	3.31	1.59-6.88	0.001*
Operative time >120 minutes	5.27	2.54-10.94	<0.001*
Estimated blood loss >250 mL	2.65	1.32-5.32	0.006*
No use of wound protector	1.76	0.78-3.96	0.175
No use of antibacterial suture	1.67	0.67-4.17	0.271
Intraoperative core temperature <36°C	2.32	1.17-4.60	0.016*

*Statistically significant (p<0.05) ASA: American Society of Anesthesiologists, BMI: Body Mass Index, CI: Confidence Interval, COPD: Chronic Obstructive Pulmonary Disease, WBC: White Blood Cell

Table 4b: Multivariate Analysis of Independent Risk Factors for Surgical Site Infection

Risk Factor	Adjusted Odds Ratio	95% CI	p-value
Open surgical approach	4.78	2.16-10.59	<0.001*
Operative time >120 minutes	3.21	1.48-6.97	0.003*
Contaminated/dirty wounds	2.87	1.31-6.28	0.008*
Preoperative serum albumin <3.0 g/dL	2.63	1.22-5.67	0.014*
Diabetes mellitus	1.87	0.84-4.17	0.126
BMI >30 kg/m²	1.78	0.71-4.45	0.219
Hemoglobin <10 g/dL	1.54	0.69-3.41	0.289
ASA grade ≥III	1.65	0.76-3.59	0.205
Intraoperative core temperature <36°C	1.46	0.67-3.19	0.342
Estimated blood loss >250 mL	1.23	0.56-2.71	0.605

*Statistically significant (p<0.05) ASA: American Society of Anesthesiologists, BMI: Body Mass Index, CI: Confidence Interval

Microbiological Profile and Antimicrobial Resistance

Culture samples were obtained from all 41 patients with SSI, with positive cultures in 36 cases (87.8%). Escherichia coli was the most commonly isolated pathogen (58.3%), followed by Klebsiella pneumoniae (16.7%), Staphylococcus aureus (13.9%), Pseudomonas aeruginosa (8.3%), and Enterococcus species (2.8%). Among the isolated pathogens, 76.4% showed resistance to the prophylactic antibiotics administered, with 63.9% exhibiting extended-spectrum β-lactamase (ESBL) production. Table 5 presents the microbiological profile and antimicrobial resistance patterns.

Table 5: Microbiological Profile and Antimicrobial Resistance Patterns

Variable	**n (%)**
Culture results (n=41)	
Positive culture	36 (87.8)
Negative culture	5 (12.2)
Isolated organisms (n=36)	
Escherichia coli	21 (58.3)
Klebsiella pneumoniae	6 (16.7)
Staphylococcus aureus	5 (13.9)
Pseudomonas aeruginosa	3 (8.3)
Enterococcus species	1 (2.8)
Antimicrobial resistance (n=36)	
Resistance to prophylactic antibiotics	27 (76.4)
ESBL producers	23 (63.9)
Methicillin-resistant S. aureus	2 (5.6)
Antibiotic sensitivity (n=36)	
Carbapenems	33 (91.7)
Piperacillin-tazobactam	27 (75.0)
Amikacin	25 (69.4)
Third-generation cephalosporins	13 (36.1)
Fluoroquinolones	10 (27.8)
Ampicillin-sulbactam	9 (25.0)

ESBL: Extended-Spectrum β-Lactamase

Clinical Outcomes

Patients who developed SSI had significantly longer mean length of hospital stay compared to those without SSI (14.7±3.2 vs. 7.3±1.8 days, $p<0.001$). Reoperation was required in 9 patients (22.0%) with SSI, primarily for wound debridement or secondary closure. The 30-day mortality rate was higher in the SSI group (7.3% vs. 2.4%, $p=0.103$), although this difference did not reach statistical significance. Table 6 summarizes the clinical outcomes in both groups.

Table 6: Clinical Outcomes in Patients with and without Surgical Site Infection

Outcome	**SSI Group (n=41)**	**Non-SSI Group (n=211)**	**p-value**
Length of hospital stay (days)			
Mean ± SD	14.7 ± 3.2	7.3 ± 1.8	<0.001*
Reoperation, n (%)	9 (22.0)	7 (3.3)	<0.001*
Reasons for reoperation, n (%)			
Wound debridement	5 (12.2)	0 (0.0)	<0.001*
Secondary closure	3 (7.3)	0 (0.0)	
Intra-abdominal collection	1 (2.4)	2 (0.9)	
Anastomotic leak	0 (0.0)	3 (1.4)	
Other	0 (0.0)	2 (0.9)	
30-day mortality, n (%)	3 (7.3)	5 (2.4)	0.103
Causes of death, n (%)			
Sepsis	2 (4.9)	1 (0.5)	0.039*
Multiorgan failure	1 (2.4)	2 (0.9)	
Cardiac events	0 (0.0)	2 (0.9)	

*Statistically significant (p<0.05) SD: Standard Deviation, SSI: Surgical Site Infection

5. DISCUSSION

This prospective observational study found an overall SSI incidence of 16.3% following emergency abdominal surgery, with open surgical approach, prolonged operative time, contaminated/dirty wounds, and preoperative hypoalbuminemia identified as independent risk factors. The findings highlight the significant burden of SSI in emergency surgical settings and underscore the need for targeted prevention strategies.

The observed SSI incidence (16.3%) in our study aligns with previous research in similar settings. Alkaaki et al. reported an SSI rate of 16.3% in abdominal surgery patients, with a higher incidence in emergency operations compared to elective procedures[6]. Similarly, Mawalla et al. found an SSI incidence of 17.12% following emergency laparotomies in a tertiary care hospital in India[8]. The Global Surgery Collaborative reported SSI rates ranging from 9.4% to 23.2% following gastrointestinal surgery, with higher rates in low- and middle-income countries[4]. These consistent findings across different geographical regions suggest that SSI remains a significant challenge in emergency abdominal surgery despite advances in surgical techniques and perioperative care.

Our study identified open surgical approach as the strongest independent risk factor for SSI (OR=4.78), consistent with findings from multiple previous studies. Zheng et al. demonstrated significantly lower SSI rates with laparoscopic surgery compared to open procedures in emergency abdominal surgery[7]. The reduced tissue trauma, smaller incisions, decreased tissue handling, and minimal exposure to external contaminants in laparoscopic surgery likely contribute to this protective effect. However, it is important to note that open surgery is often unavoidable in emergency settings due to the nature of pathology, technical difficulties, or hemodynamic instability of patients. Therefore, efforts should focus on optimizing other modifiable risk factors when laparoscopic approach is not feasible.

Prolonged operative time (>120 minutes) emerged as another significant risk factor (OR=3.21) in our analysis. This association has been consistently reported in previous studies, including work by Kim et al. who identified prolonged operation time as an independent risk factor for SSI after gastric surgery[12]. Extended surgical duration increases tissue exposure to potential contaminants, prolongs tissue desiccation, and may reflect complex pathology or technical difficulties. Strategies to minimize operative time without compromising surgical quality, such as appropriate surgical planning, skilled assistance, and optimal instrument availability, may help reduce SSI risk in emergency settings.

Wound classification, particularly contaminated or dirty wounds, was significantly associated with SSI development (OR=2.87). This finding aligns with established surgical principles and previous research showing increased infection rates with higher degrees of contamination. Hassan et al. reported similar findings in their study of emergency surgery patients, with contaminated wounds carrying significantly higher SSI risk[14]. In emergency abdominal surgery, particularly for conditions such as hollow viscus perforation or bowel obstruction with gangrenous changes, contamination is often unavoidable. Therefore, meticulous technique, thorough peritoneal lavage, and appropriate antibiotic therapy become crucial preventive measures.

Preoperative hypoalbuminemia (<3.0 g/dL) was identified as an independent risk factor for SSI (OR=2.63), highlighting the importance of nutritional status in wound healing and infection resistance. Huda et al. similarly found a significant association between low serum total protein and SSI development in patients undergoing laparotomy[11]. Albumin plays a critical role in maintaining oncotic pressure, transporting nutrients, and supporting the immune system. Low albumin levels may reflect poor nutritional status, chronic disease, or ongoing inflammation, all of which compromise wound healing and increase susceptibility to infection. Although emergency settings offer limited opportunity for preoperative nutritional optimization, early postoperative nutritional support may help mitigate this risk.

The microbiological profile in our study revealed a predominance of gram-negative organisms, with Escherichia coli being the most commonly isolated pathogen (58.3%). This finding is consistent with previous studies in abdominal surgery, reflecting the typical gut flora encountered in these procedures. Alkaaki et al. similarly found extended-spectrum β-lactamase-producing Escherichia coli as the most commonly isolated organism in their cohort[6]. The high rate of antimicrobial resistance observed in our study, with 76.4% of isolates showing resistance to prophylactic antibiotics and 63.9% exhibiting ESBL production, is concerning. This pattern underscores the need for institution-specific antibiotic protocols based on local resistance patterns and judicious use of broad-spectrum antibiotics to prevent further emergence of resistance.

The clinical impact of SSI was evidenced by significantly prolonged hospital stay (14.7±3.2 vs. 7.3±1.8 days, $p<0.001$) and higher reoperation rates (22.0% vs. 3.3%, $p<0.001$) in affected patients. These findings align with global data on the economic burden of SSIs, with estimates suggesting that SSIs double the length of hospital stay and significantly increase healthcare costs[2]. While our study did not specifically analyze cost implications, the extended hospitalization and additional interventions required for SSI management undoubtedly translate to substantial resource utilization. In resource-constrained settings, prevention of SSI becomes even more critical from both clinical and economic perspectives.

Several interventions have shown promise in reducing SSI rates in emergency abdominal surgery. These include appropriate antibiotic prophylaxis, maintenance of normothermia, glycemic control, minimally invasive techniques when feasible, meticulous surgical technique, and protocol-driven perioperative care. The World Health Organization's Global Guidelines for the Prevention of Surgical Site Infection provide comprehensive recommendations, though many are based on evidence from elective surgery[8]. Adoption of surgical care bundles, which combine multiple evidence-based interventions, has demonstrated effectiveness in reducing SSI rates across various surgical specialties.

Our study has several strengths, including its prospective design, comprehensive assessment of potential risk factors, standardized SSI diagnosis based on CDC criteria, and complete 30-day follow-up. However, certain limitations warrant consideration. As a single-center study, the findings may not be fully generalizable to all settings. The observational nature precludes definitive conclusions about causality. Additionally, we did not assess the impact of specific preventive interventions, which would require a randomized controlled design. Future multicenter studies evaluating targeted prevention strategies based on identified risk factors would provide valuable evidence to guide clinical practice.

6. CONCLUSION

This prospective study demonstrated a significant incidence of surgical site infections following emergency abdominal surgery, with open surgical approach, prolonged operative time, contaminated/dirty wounds, and preoperative hypoalbuminemia identified as independent risk factors. The high rate of antimicrobial resistance among isolated pathogens and the substantial impact of SSI on clinical outcomes highlight the need for targeted prevention strategies. Implementation of comprehensive infection control measures, appropriate antibiotic stewardship, and optimization of modifiable risk factors may reduce SSI rates and improve patient outcomes in this high-risk population. Institution-specific protocols based on local microbiological profiles and resistance patterns are essential for effective SSI prevention in emergency abdominal surgery.

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