

Incidence of surgical site infection following elective vs emergency laparotomy surgeries, the microorganisms isolated and their sensitivity pattern: a prospective, comparative, observational, single center study

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Abstract

Background

Surgical site infection (SSI) is a common healthcare-associated infection after abdominal surgery, leading to increased morbidity, prolonged hospital stay, and higher healthcare costs. Emergency laparotomy is considered to carry a greater risk of SSI than elective surgery because of increased wound contamination and limited preoperative optimisation.

Aim and Objective

To compare the occurrence of SSI between emergency and elective laparotomy patients and to identify the predominant microorganisms and their antibiotic sensitivity patterns.

Materials and Methods

A prospective, single-centre, comparative observational study was conducted at DY Patil Hospital, Nerul, Navi Mumbai, from June 2022 to June 2024. A total of 100 patients undergoing laparotomy (50 emergency and 50 elective) were enrolled. Patients were followed for 30 days postoperatively for SSI surveillance. Wound specimens were cultured using standard microbiological techniques, and antibiotic susceptibility testing was performed using the Kirby-Bauer disc diffusion method according to CLSI guidelines.

Results

SSI occurred in 62% of emergency cases and 30% of elective cases. Wound contamination was more common in the emergency group (90% vs. 36%). The predominant isolates were *Escherichia coli* (22.58% in emergency and 20% in elective cases) and *Klebsiella pneumoniae* (19.35% and 26.7%, respectively). Most isolates were sensitive to amikacin, meropenem, vancomycin, and linezolid. Escalation of antibiotic therapy based on culture sensitivity was the most common management approach.

Conclusion

Emergency laparotomy is associated with a higher burden of SSI than elective surgery, likely due to greater contamination and limited preoperative preparation. Gram-negative organisms predominate, highlighting the importance of culture-guided antimicrobial therapy. Routine SSI surveillance, strict infection-control practices, optimisation of patient-related risk factors, and rational antibiotic stewardship are recommended to reduce SSI and improve postoperative outcomes.

Keywords: Surgical site infection, laparotomy, emergency surgery, elective surgery, microorganisms, antibiotic sensitivity, wound contamination, *Escherichia coli*, *Klebsiella pneumoniae*.

Submitted; January 20, 2026.

Accepted; May 12, 2026.

Published; June 1, 2026

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Introduction

Surgical site infection (SSI) continues to represent a significant burden in surgical practice despite considerable advances in operative technique, anaesthesia, and perioperative care. The Centers for Disease Control and

Prevention define SSI as a wound infection occurring within 30 days of a surgical procedure, or within one year when an implant is in situ and the infection is causally related to surgery.¹ SSIs are classified as the second most frequent healthcare-associated infection after catheter-

related infections.² They are associated with prolonged hospital stay, increased patient mortality, the need for re-intervention, and substantial economic burden to healthcare systems.³ SSI occurs following approximately 1–3% of all surgical procedures; however, abdominal surgery carries a disproportionately higher risk, with several prospective studies reporting prevalence rates between 15 and 25%, depending on the degree of wound contamination.⁴

The risk of SSI is compounded by a growing population of surgical patients with significant comorbidities such as obesity, type 2 diabetes mellitus, cardiovascular disease, and malignancy.⁵ Obesity in particular impairs wound healing through adipose tissue hypoperfusion, creation of dead space, and prolonged operative time, each independently increasing SSI risk.^{6,7} Diabetes mellitus, through its negative effects on immune function and microvascular supply, further predisposes patients to postoperative wound complications.⁸ The degree of bacterial contamination at the operative site, duration of surgery, and host-related factors including immune suppression and malnutrition together determine SSI development.⁴ The American College of Surgeons wound classification system stratifies surgical wounds into four classes — clean (SSI risk 1–3%), clean-contaminated (5–8%), contaminated (20–25%), and dirty (30–40%) — with emergency surgery increasing infection risk across all wound classes.⁹

The microbial aetiology of SSI following abdominal surgery is predominantly derived from the patient's endogenous flora. The most frequently isolated organisms include *Staphylococcus aureus*, coagulase-negative staphylococci, *Enterococcus* species, and *Escherichia coli*.¹⁰ In descending order of frequency, *Staphylococcus aureus* (sensitive to vancomycin and linezolid), *Enterobacteriaceae* species (sensitive to imipenem), and *Pseudomonas aeruginosa* account for the majority of SSI pathogens.¹¹ The National Nosocomial Infection Surveillance Programme defines SSIs across three anatomical levels: superficial incisional, deep incisional, and organ/space infections.¹² A rising burden of multidrug-resistant organisms has further complicated SSI management, underscoring the need for site-specific microbiological data and rational antibiotic stewardship. The present study was therefore undertaken to compare SSI incidence between emergency and elective laparotomy, identify the predominant organisms, and characterise their antibiotic sensitivity profiles.

Methodology

Study Design

This was a prospective cross-sectional comparative study conducted to compare the occurrence of surgical site infection (SSI) among patients undergoing elective and emergency laparotomy and to evaluate the associated microorganisms and their antimicrobial sensitivity patterns.

Study Setting

The study was conducted in the Department of General Surgery at Dr. D. Y. Patil Hospital and Research Centre, Nerul, Navi Mumbai, Maharashtra, a tertiary care teaching hospital. The study period extended from June 2022 to June 2024.

Study Population

The study population comprised adult patients undergoing elective or emergency abdominal laparotomy during the study period.

Sampling Method

Eligible patients were recruited using consecutive sampling until the required sample size was achieved. Participants were allocated into two groups: Emergency Laparotomy Group (Group A, n=50) and Elective Laparotomy Group (Group B, n=50).

Eligibility Criteria

Inclusion Criteria

- Patients aged ≥ 18 years of either sex.
- Patients undergoing clean, clean-contaminated, contaminated, or dirty elective or emergency abdominal surgeries.
- Patients willing to provide written informed consent.

Exclusion Criteria

- Patients aged < 18 years.
- HIV-positive patients.
- Patients receiving long-term corticosteroid therapy.
- Patients undergoing vascular, gynaecological, urological, or plastic surgical procedures.
- Patients with wounds that were difficult to close primarily.

- Patients unwilling to participate.

Sample Size Determination

The sample size was calculated using a two-proportion one-sided test for comparison of SSI occurrence between emergency and elective laparotomy groups, assuming a significance level (α) of 0.05 and statistical power of 80%. Based on the expected difference in SSI occurrence between the groups, a minimum sample size of 100 patients was determined, with 50 patients in each group.

Study Outcomes

Primary Outcome

- Occurrence of Surgical Site Infection (SSI), defined according to the Centers for Disease Control and Prevention (CDC) criteria within 30 days following surgery.

Secondary Outcome

- Microorganisms isolated from infected wounds.
- Antibiotic sensitivity patterns of isolated organisms.

Clinical and Laboratory Parameters

- Demographic characteristics (age, sex).
- Laboratory parameters (haemoglobin, total leucocyte count, platelet count, packed cell volume, serum sodium, potassium, chloride, creatinine, and albumin).
- Wound classification.
- Type of surgery (elective or emergency).
- Antibiotic management strategies.

Data Collection Methods

Data were collected using a predesigned and pretested case record proforma. Demographic details, clinical findings, laboratory investigations, operative details, and postoperative outcomes were recorded.

All patients received prophylactic antibiotics (metronidazole and an aminoglycoside) one hour before surgery according to institutional protocol. Surgical

wounds were assessed on postoperative days 3, 5, and 7 and subsequently at weekly intervals for 30 days using CDC SSI criteria.

For microbiological evaluation, two sterile wound swabs were collected from infected wounds. One swab was used for Gram staining, while the other was inoculated onto MacConkey agar, blood agar, chocolate agar, and thioglycolate broth for culture. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Bias and Measures to Minimise Bias

Selection bias was minimised through consecutive recruitment of all eligible patients during the study period. Information bias was reduced by using a standardised data collection proforma and uniform CDC criteria for SSI diagnosis. Laboratory bias was minimised by following standard microbiological procedures and CLSI guidelines for antimicrobial susceptibility testing. Observer bias was reduced through uniform postoperative wound assessment protocols.

Statistical Analysis

Data were entered into Microsoft Excel (Version 365) and analysed using MedCalc Statistical Software (Version 19.0.6). Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were expressed as frequencies and percentages. Comparisons between groups were performed using the two-sample mean test and Chi-square/Fisher's exact test where appropriate. Two-way ANOVA was used for comparisons across different time intervals. A p-value <0.05 was considered statistically significant.

Ethical Considerations and Informed Consent

The study was approved by the Institutional Ethics Committee of Dr. D. Y. Patil Hospital and Research Centre, Nerul, Navi Mumbai (IEC Ref. No. DYP/IECBH/2023/056). Written informed consent was obtained from all participants prior to enrolment. Confidentiality and anonymity of participant data were maintained throughout the study, and participation was entirely voluntary.

Results

During the study period, 100 patients undergoing laparotomy were assessed for eligibility. Of these, 100 fulfilled the inclusion criteria, provided informed consent, and were enrolled in the study. Fifty patients underwent

emergency laparotomy (Group A) and 50 underwent elective laparotomy (Group B). No enrolled participants were lost to follow-up during the 30-day postoperative surveillance period, and data from all 100 patients were included in the final analysis. A participant flow diagram is provided in Figure 1.

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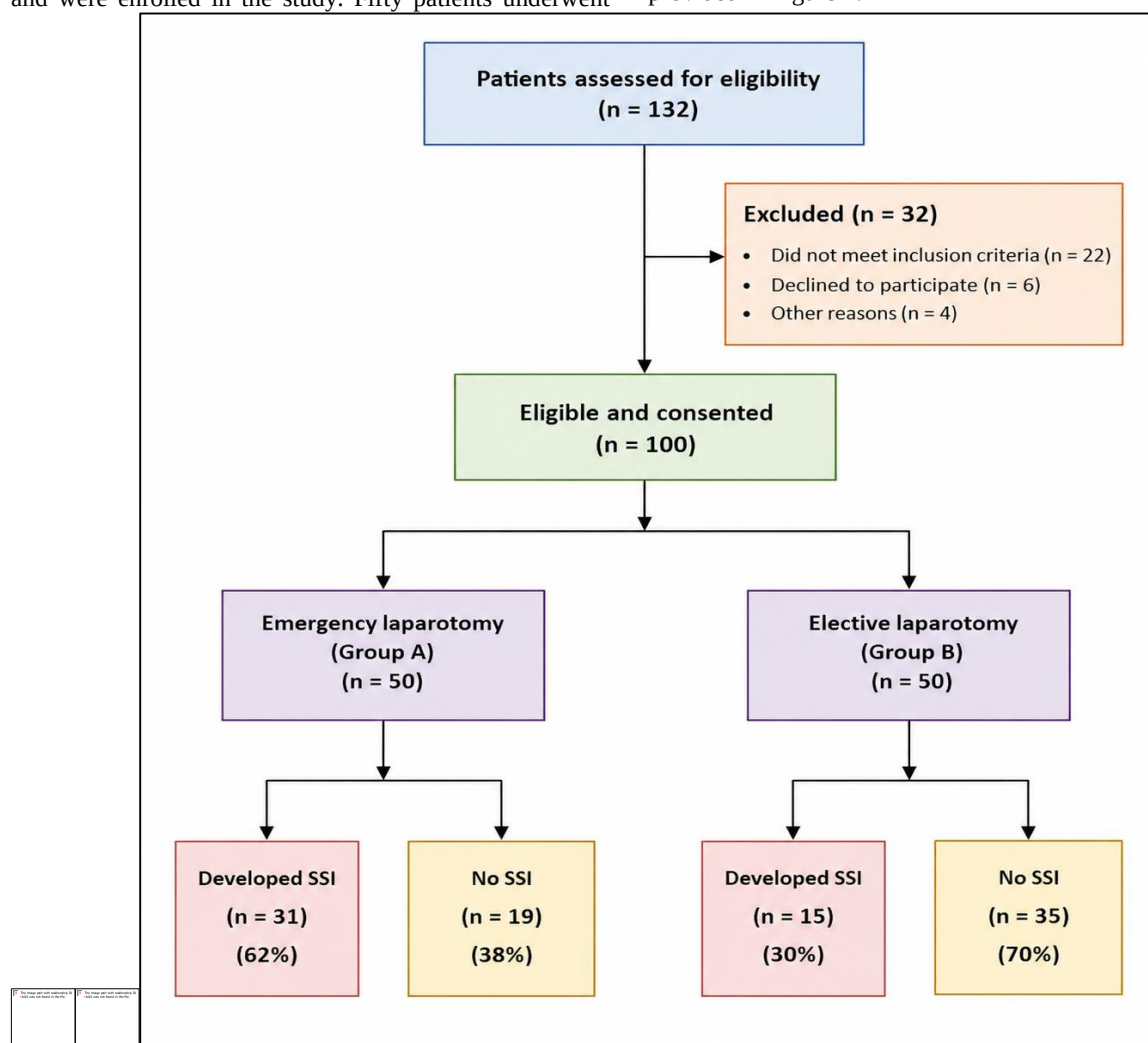


Fig1: Study Flow Diagram Showing Patient Enrollment and SSI Outcomes in Emergency and Elective Laparotomy Groups

Baseline Characteristics

A total of 100 patients were included in the study, with 50 patients each in the emergency and elective laparotomy groups. The largest proportion of patients (27%) belonged to the 31–45-year age group. Patients undergoing emergency laparotomy tended to be younger, with 30% aged 18–30 years, whereas the elective group had a greater proportion of patients aged 46–60 years (32%). The mean age was comparable between the two groups (44.12 ± 19.36 years in the emergency group and 47.20 ± 15.54 years in

the elective group; $p=0.3825$). Males constituted 60% of the study population, resulting in a male-to-female ratio of 1.5:1.

Elevated HbA1c levels ($>6\%$) were observed in 22% of patients in both groups. Most patients (85%) required an ICU stay of 1–3 days following surgery. Wound contamination was considerably more common among patients undergoing emergency laparotomy (90%) compared with those undergoing elective procedures (36%). Conversely, the use of abdominal and subcutaneous

drains was more frequent in the elective group (88% vs. 66%).

Laboratory Parameters

Comparison of preoperative and postoperative laboratory parameters showed a mild decline in haemoglobin levels in both groups, consistent with perioperative blood loss. Serum albumin levels also decreased following surgery, reflecting the metabolic and inflammatory response associated with major abdominal procedures. An increase in total leucocyte count was observed postoperatively, indicating the expected systemic inflammatory response to surgery.

Surgical Site Infection and Microbiological Profile

Among the 100 patients studied, 46 developed surgical site infection, giving an overall SSI incidence of 46 per 100 operated patients (46%). The incidence was notably higher in the emergency laparotomy group, where 31 of 50 patients (62%) developed SSI, compared with 15 of 50 patients (30%) in the elective laparotomy group.

Microbiological analysis revealed that *Escherichia coli* and *Klebsiella pneumoniae* were the most commonly isolated pathogens in both groups. *E. coli* accounted for 22.58% of isolates in the emergency group and 20% in the elective group, while *K. pneumoniae* accounted for 19.35% and 26.7% of isolates, respectively. Serous wound discharge was the most frequent clinical presentation and was observed more commonly among emergency cases. The distribution of discharge types differed significantly between the two groups ($p=0.0183$).

Antibiotic Sensitivity and Management

Antibiotic susceptibility testing demonstrated that most isolates were sensitive to amikacin, meropenem, other aminoglycosides, and carbapenems. Gram-positive organisms showed good susceptibility to vancomycin, linezolid, and teicoplanin. Culture-guided modification of antibiotic therapy was required in 51.61% of patients in the emergency group and 38.71% of patients in the elective group, while the remaining patients were managed with empirical antibiotic regimens.

Discussions

Key findings

The primary objective of this study was to compare the incidence of surgical site infection (SSI) following emergency and elective laparotomy. The study

demonstrated a significantly higher incidence of SSI among patients undergoing emergency laparotomy (62%) than elective laparotomy (30%). Emergency procedures were also associated with a substantially higher rate of wound contamination (90% vs. 36%), indicating contamination as an important contributor to postoperative infection.

The second objective was to identify the microorganisms responsible for SSI. Gram-negative bacteria predominated in both groups, with *Escherichia coli* and *Klebsiella pneumoniae* being the most frequently isolated pathogens. The third objective was to determine their antimicrobial susceptibility pattern. Most isolates remained susceptible to amikacin, meropenem, vancomycin, and linezolid, while antibiotic therapy was frequently escalated based on culture sensitivity, particularly among emergency cases.

Interpretation of the findings

The higher incidence of SSI following emergency laparotomy is likely attributable to the inability to adequately optimize patients before surgery, the greater degree of wound contamination, and the urgent nature of these procedures. Emergency surgeries often involve perforation peritonitis, bowel obstruction, or traumatic abdominal pathology, all of which increase bacterial contamination and compromise host defence mechanisms.

The predominance of Gram-negative organisms observed in the present study reflects the endogenous gastrointestinal flora encountered during abdominal surgery. The observed antimicrobial susceptibility pattern suggests that although resistance is increasing, aminoglycosides, carbapenems, and glycopeptides continue to provide effective treatment against most isolates in our institution. These findings reinforce the importance of obtaining culture and sensitivity reports before modifying antimicrobial therapy and support the principles of antimicrobial stewardship.

Comparison with previous studies

The present findings are consistent with those reported by Ray et al. (2022), who observed a markedly higher SSI rate following emergency laparotomy than elective procedures (73.5% vs. 26.5%). Similarly, Jatoliya et al. (2023) reported higher SSI rates among emergency abdominal surgeries (26%) compared with elective surgeries (8%). These studies, together with the present findings, demonstrate that emergency abdominal surgery consistently carries a greater risk of postoperative wound infection.

The predominance of *Escherichia coli* and *Klebsiella pneumoniae* observed in this study is also comparable with reports by Chaudhari and Shah, Thummar et al., and Bhatiani et al., who identified Gram-negative bacilli as the

principal pathogens responsible for postoperative abdominal SSI. This similarity likely reflects the endogenous gastrointestinal flora commonly encountered during laparotomy.

The antimicrobial susceptibility profile observed in this study also agrees with previous Indian studies demonstrating good activity of amikacin and carbapenems against Gram-negative organisms and excellent susceptibility of Gram-positive isolates to vancomycin and linezolid. However, the presence of intermediate susceptibility to colistin among certain isolates indicates the emergence of multidrug resistance and highlights the need for judicious antibiotic use and continuous microbiological surveillance.

Generalizability of the study findings

The findings of this study are likely to be generalizable to tertiary care hospitals managing similar emergency and elective abdominal surgical patients in resource-limited settings, particularly where the spectrum of surgical diseases, infection control practices, and microbial flora are comparable. However, microbiological profiles and antimicrobial resistance patterns vary across institutions and geographical regions. Therefore, local antibiograms should continue to guide empirical antibiotic selection, and multicentre studies are required before these findings can be generalized to broader populations.

Strengths of the study

The prospective comparative design, standardized postoperative surveillance for 30 days using CDC criteria, and microbiological confirmation with culture and antimicrobial susceptibility testing strengthen the validity of the study findings. The inclusion of both emergency and elective laparotomy patients enabled direct comparison of infection rates and microbial characteristics under similar institutional conditions.

Limitations

This study has several limitations. First, it was conducted at a single tertiary care centre, which may limit the generalizability of the findings. Second, the sample size was relatively small, with only 100 participants, potentially limiting the power to detect associations with less common risk factors. Third, the study included a heterogeneous population of abdominal surgical procedures, which may have introduced procedural variability affecting SSI risk. Fourth, postoperative follow-up was limited to 30 days, and late-onset infections occurring beyond this period may not

have been captured. Finally, factors such as surgeon experience, operative duration, and adherence to perioperative infection-control measures were not analysed separately and may have influenced the occurrence of SSI.

Conclusion

Emergency laparotomy is associated with a significantly higher incidence of surgical site infection than elective laparotomy, primarily because of greater wound contamination and limited opportunity for preoperative optimization. *Escherichia coli* and *Klebsiella pneumoniae* were the predominant pathogens isolated, with most organisms remaining susceptible to amikacin, meropenem, vancomycin, and linezolid. These findings emphasize the importance of meticulous perioperative infection control measures, routine culture and sensitivity testing, rational antimicrobial stewardship, and optimization of patient-related risk factors to reduce the burden of SSI and improve postoperative outcomes. Larger multicentre studies are recommended to validate these findings and monitor evolving antimicrobial resistance patterns.

Recommendations

Based on the findings of the present study, routine surveillance for surgical site infections should be strengthened, particularly among patients undergoing emergency laparotomy. Optimisation of modifiable risk factors such as anaemia, hypoalbuminaemia, and poor glycaemic control, along with strict adherence to aseptic surgical techniques and infection-control measures, may help reduce SSI occurrence. Early microbiological evaluation and culture-guided antibiotic therapy should be encouraged to improve treatment outcomes and support antimicrobial stewardship. Further multicentre studies with larger sample sizes are recommended to validate these findings and better define the risk factors, microbiological profile, and antimicrobial sensitivity patterns associated with surgical site infections following laparotomy.

Acknowledgment

We express our sincere gratitude to the Department of General Surgery, Dr. D. Y. Patil Hospital and Research Centre, Nerul, Navi Mumbai, for providing the necessary facilities and support for conducting this study. We also thank the Department of Microbiology for their valuable assistance in culture and antimicrobial sensitivity testing. Special appreciation is extended to all the patients who voluntarily participated in this study and made this research possible.

Abbreviations

Abbreviation	Full Form
SSI	Surgical Site Infection
CDC	Centers for Disease Control and Prevention
CLSI	Clinical and Laboratory Standards Institute
ICU	Intensive Care Unit
HbA1c	Glycated Hemoglobin
Hb	Hemoglobin
TLC	Total Leukocyte Count
PCV	Packed Cell Volume
IEC	Institutional Ethics Committee
SD	Standard Deviation
ANOVA	Analysis of Variance
MRCONS	Methicillin-Resistant Coagulase-Negative Staphylococci
<i>E. coli</i>	<i>Escherichia coli</i>

Source of Funding

No funding was received from any governmental, commercial, or non-profit funding agency for the conduct of this study.

Conflict of Interest

There are no conflicts of interest related to this study.

Author Contributions

Nidhi Shah contributed to study conception and design, data collection, data analysis, interpretation of results, and manuscript drafting. Sandesh Deolekar contributed to study supervision, methodological guidance, interpretation of findings, critical revision of the manuscript, and final approval of the version to be published. Shashank Jain, Aashay Shah, Shivani Vichare, Ritu Patil, Adnan Bijapu, and Deepanshi Shah contributed to data collection, patient recruitment, data interpretation, literature review, and manuscript preparation. All authors reviewed, revised, and approved the final manuscript and agree to be accountable for all aspects of the work.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Student's Journal of Health Research Africa

e-ISSN: 2709-9997, p-ISSN: 3006-1059

Vol.7 No. 2 (2026): June 2026 Issue

<https://doi.org/10.51168/k935r493>

Original Article

PUBLISHER DETAILS

Student's Journal of Health Research (SJHR)

(ISSN 2709-9997) Online

(ISSN 3006-1059) Print

Category: Non-Governmental & Non-profit Organization

Email: studentsjournal2020@gmail.com

WhatsApp: +256 775 434 261

Location: Scholar's Summit Nakigalala, P. O. Box 701432,
Entebbe Uganda, East Africa

