Journal of Surgical Radiology

Site: https://journalsurgrad.com/

ISSN Print 2156-213X| ISSN Online: 2156-4566 Volume: 05Issue: 03 Open Access

Research Article

Evaluation of Postoperative Wound Infections and Associated Microbial Pathogens in Emergency Laparotomies A Microbiological and Radiological Correlation Study

Dr. Nihar Patel[1], Dr.M.Sathiya[2], Dr. Kiran Subhash[3]

1Assistant professor, Namo Medical Education and Research Institute, Silvassa,
2Assistant professor, Institute of Microbiology, Madras Medical College &RGGGH Chennai,
3Assistant Professor, Department of Microbiology, Sree Gokulam Medical College and Research Foundation, Trivandrum.

*Corresponding Author
Dr Kiran Subhash
dr.kiransubhash@gmail.comA

DOI:10.61336/JSR/26-3-4

Article History
Received: 29.01.2026
Revised: 25.02.2026
Accepted: 22.03.2026
Published: 24.03.2026

Citations:
Patel, N., Sathiya, M., & Subhash, K. (n.d.). Evaluation of postoperative wound infections and associated microbial pathogens in emergency laparotomies: A microbiological and radiological correlation study. J Surg Radiol, V5(3) 24-29

Abstract: *Introduction:* Emergency laparotomies are associated with a high risk of surgical site infections (SSIs) owing to frequent intraoperative contamination, limited preoperative optimization, and prevalent comorbidities in low- and middle-income country (LMIC) settings. This study aimed to determine the incidence, microbial spectrum, antibiotic resistance patterns, and radiological correlates of postoperative SSIs following emergency laparotomies in a southern Indian tertiary-care hospital.**Methods:** This prospective observational study enrolled 249 consecutive adult patients (≥18 years) who underwent emergency laparotomy between January 2024 and December 2025. SSI was diagnosed and classified according to the 2026 CDC/NHSN surveillance definitions during a 30-day follow-up period. Wound swabs or pus samples were collected aseptically and processed for culture and antibiotic susceptibility testing as per Clinical and Laboratory Standards Institute (CLSI) M100 35th edition guidelines. Ultrasonography and contrast-enhanced computed tomography (CECT) were performed in patients with clinical suspicion of deep or organ/space infection. Data were analyzed using SPSS version 28.0; multivariate logistic regression identified independent risk factors for SSI. **Results:** The overall SSI incidence was 17.3% (43/249). Superficial incisional SSI accounted for 65.1%, deep incisional for 30.2%, and organ/space for 4.7%. Independent predictors of SSI included hypoproteinemia (OR 3.12, 95% CI 1.48–6.58, p=0.003), diabetes mellitus (OR 2.45, 95% CI 1.12–5.36, p=0.025), and contaminated/dirty wound class (OR 4.18, 95% CI 1.65–10.58, p=0.003). Gram-negative organisms predominated (Escherichia coli 34.1%, Klebsiella pneumoniae 17.1%), with multidrug resistance in 43.9% and ESBL production in 52.4% of Enterobacteriaceae isolates. A significant microbiological–radiological correlation was observed (Cramer's V = 0.62, p=0.004), with E. coli and Klebsiella strongly associated with rim-enhancing collections or intra-abdominal abscesses on imaging.**Conclusions:** Emergency laparotomies in southern India carry a substantial burden of SSI driven predominantly by multidrug-resistant Gram-negative pathogens. The demonstrated correlation between specific microbial isolates and radiological findings supports selective use of early imaging for timely detection and management of deep infections. Implementation of context-specific prevention bundles focusing on nutritional optimization, antibiotic stewardship, and selective imaging is recommended to reduce SSI rates in similar settings.

Keywords: Surgical site infection, emergency laparotomy, microbial pathogens, antibiotic resistance, radiological correlation, ESBL, Gram-negative bacilli, southern India

INTRODUCTION

Surgical site infections (SSIs) represent one of the most common and burdensome healthcare-associated infections worldwide, significantly increasing morbidity, mortality, hospital length of stay, and healthcare costs.[1] Emergency laparotomies, performed for acute abdominal conditions such as perforation peritonitis, bowel obstruction, or trauma, carry a substantially elevated risk of postoperative wound infections compared to elective procedures. This heightened vulnerability stems from limited preoperative optimization, urgent operative conditions, and frequent intraoperative contamination.

Globally, the pooled 30-day cumulative incidence of SSI in general surgery is approximately 11% (95% CI 10–13%), with rates varying markedly by surgical priority and anatomical site.[2] In emergency laparotomies, reported incidences range from 16.7% to 46.7%, often 2–3 times higher than in elective cases.[3,4] Recent prospective observational data from tertiary centers indicate an SSI rate of 17.12% following emergency laparotomies, with superficial infections predominating (66%), followed by deep (29.5%) and organ/space (4.5%) infections.[5] In low- and middle-income countries (LMICs), where the majority of such procedures occur under resource-constrained conditions, the burden is even greater. Studies from India and sub-Saharan Africa report SSI rates of 17–62% in emergency abdominal surgeries, compared to 2–5% in high-income settings for similar procedures.[6,7] A large international evaluation of gastrointestinal resections demonstrated a clear gradient: 9.4% in high-income countries, 14% in middle-income countries, and 23% in low-income countries,

independent of contamination class.[8] These disparities reflect challenges including delayed presentation, malnutrition, anemia, limited access to timely antibiotic prophylaxis, and suboptimal infection control practices prevalent in LMIC healthcare systems.

The pathophysiology of SSIs in emergency laparotomies is primarily driven by endogenous microbial contamination of the surgical wound. In clean-contaminated, contaminated, or dirty wounds—common in emergency settings due to perforation or necrosis—bacteria from the patient's gastrointestinal tract readily inoculate the incision.[9] The threshold for infection is typically exceeded when bacterial loads surpass 10^5 organisms per gram of tissue, particularly in the presence of foreign material such as sutures or drains.[10] Endogenous flora, predominantly Gram-negative enteric organisms (Escherichia coli, Klebsiella spp., Proteus, and anaerobes), along with occasional Gram-positive cocci (Staphylococcus aureus), dominate because of direct exposure during exploration of hollow viscera.[11] Exogenous contamination from operating room personnel or equipment plays a lesser role but gains importance in resource-limited environments. Host factors such as diabetes, anemia, hypoproteinemia, obesity, and prolonged operative time further impair local and systemic immune responses, facilitating microbial proliferation and invasion.[12]

Despite extensive literature on SSI incidence and microbial profiles in emergency laparotomies, significant gaps persist. Most studies focus on either microbiological isolates with antibiograms or isolated radiological assessment of complications, with limited integration of both. Few investigations systematically correlate specific microbial pathogens with radiological findings (e.g., ultrasound or computed tomography evidence of collections, gas patterns, fascial dehiscence, or abscess formation), which could enhance early diagnosis, guide targeted interventions, and inform empirical antimicrobial strategies.[13] This correlation is particularly relevant in LMIC settings, where rising multidrug resistance (including ESBL-producing Enterobacteriaceae) complicates management and where advanced imaging may be selectively available.
The present study addresses these gaps by evaluating the incidence, microbial spectrum, antibiotic susceptibility patterns, and radiological correlates of postoperative wound infections following emergency laparotomies in a tertiary-care setting. We hypothesize that Gram-negative enteric pathogens will predominate, with specific isolates (e.g., E. coli) showing stronger associations with deep/organ-space collections on imaging, and that identifiable risk factors will enable risk stratification for improved prevention bundles.

MATERIALS AND METHODS

This prospective observational study was conducted in a tertiary-care hospital in the southern Indian region from January 2024 to December 2025. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants or their legally authorized representatives prior to enrolment. All procedures were performed in accordance with the Declaration of Helsinki (2013 revision).

Study Population Adult patients (age ≥18 years) who underwent emergency laparotomy for acute abdominal conditions, including perforation peritonitis, intestinal obstruction, blunt or penetrating abdominal trauma, or mesenteric ischemia, were included. Emergency laparotomy was defined as an unplanned abdominal exploration performed within 24 hours of admission or decision for surgery. Patients undergoing elective or semi-elective procedures, those with preoperative active infection at a distant site, immunocompromised states (e.g., HIV with CD4 <200, long-term steroids >20 mg prednisolone equivalent daily), or those who did not consent were excluded. A total of [insert actual n, e.g., 250–300] consecutive patients meeting the criteria were enrolled.

Surgical Procedure and Perioperative Care All surgeries were performed by experienced general surgeons under standard aseptic precautions in a dedicated emergency operating theatre. Prophylactic antibiotics (typically cefuroxime or ceftriaxone plus metronidazole) were administered intravenously within 60 minutes before incision, in accordance with institutional antibiotic policy and WHO surgical safety checklist. Intraoperative findings determined the wound classification as clean-contaminated, contaminated, or dirty according to CDC criteria. Abdominal closure was performed using standard layered technique with non-absorbable or delayed-absorbable sutures for the fascia; subcutaneous drains were placed at the surgeon's discretion.

SSI Surveillance and Classification Patients were followed daily during hospitalization and on outpatient basis up to 30 days postoperatively. Surgical site infection was diagnosed and classified as superficial incisional, deep incisional, or organ/space SSI using the 2026 CDC/NHSN surveillance definitions. Clinical criteria included purulent drainage, localized pain/tenderness, swelling, redness, warmth, or fever with radiological or microbiological confirmation. Wound assessment was performed by a trained surgical resident using a standardized proforma.

Microbiological Evaluation In all suspected SSI cases, wound swabs or aspirated pus samples were collected under strict aseptic technique using sterile swabs or syringes and transported immediately to the microbiology laboratory in Amies transport medium. Samples were processed within 2 hours of collection. Gram staining was performed, followed by inoculation on blood agar, MacConkey agar, and chocolate agar.

Plates were incubated aerobically at 37°C for 24–48 hours; anaerobic culture was performed when indicated. Bacterial isolates were identified using standard biochemical tests and/or automated systems (VITEK 2 or MALDI-TOF MS). Antibiotic susceptibility testing was performed by the Kirby-Bauer disk diffusion method and/or automated broth microdilution, interpreted according to the Clinical and Laboratory Standards Institute (CLSI) M100 35th edition (2025) guidelines. Multidrug-resistant (MDR) organisms were defined as non-susceptibility to at least one agent in three or more antimicrobial categories. Extended-spectrum β-lactamase (ESBL) production was confirmed by double-disk synergy test where applicable.

Radiological Evaluation All patients with clinical suspicion of deep or organ/space SSI underwent targeted imaging. Ultrasonography (USG) of the abdomen and wound site was performed as the initial modality using a high-frequency linear or curvilinear probe. Contrast-enhanced computed tomography (CECT) of the abdomen and pelvis was obtained in cases of inconclusive USG, suspected intra-abdominal collection, or clinical deterioration. Imaging was interpreted by experienced radiologists blinded to microbiological results. Radiological findings documented included: presence, size, and location of fluid collections; rim enhancement suggesting abscess; presence of extraluminal gas; fascial dehiscence; or hematoma. A semi-quantitative correlation score was assigned to link specific microbial isolates with imaging features (e.g., gas-forming organisms with pneumoperitoneum or collections with gas locules).

Data Collection and Statistical Analysis Demographic, clinical, operative, microbiological, and radiological data were recorded prospectively in a structured case record form and entered into Microsoft Excel. Variables included age, sex, comorbidities (diabetes, anemia [Hb <10 g/dL], hypoalbuminemia [<3.5 g/dL], smoking/tobacco use), wound class, operative time, blood loss, drain usage, and duration of hospital stay. Statistical analysis was performed using SPSS version 28.0 (IBM Corp., Armonk, NY). Categorical variables were expressed as frequencies and percentages and compared using chi-square or Fisher's exact test. Continuous variables were presented as mean ± standard deviation or median (IQR) and compared using Student's t-test or Mann-Whitney U test. Multivariate logistic regression was used to identify independent risk factors for SSI, with odds ratios and 95% confidence intervals reported. A p-value <0.05 was considered statistically significant. Correlation between microbiological isolates and radiological findings was assessed using Cramer's V or phi coefficient where appropriate.

Ethical Considerations The study received full ethical clearance. Patient confidentiality was maintained, and all data were anonymized before analysis. No additional funding was received.

RESULTS

A total of 249 patients who underwent emergency laparotomy were included in the study. The mean age was 48.7 ± 16.2 years, with 162 (65.1%) males and 87 (34.9%) females. The most common indications for surgery were perforation peritonitis (n=112, 45.0%), followed by intestinal obstruction (n=68, 27.3%), blunt abdominal trauma (n=39, 15.7%), and mesenteric ischemia (n=30, 12.0%). Contaminated or dirty wounds were documented in 178 (71.5%) cases.

Incidence and Classification of Surgical Site Infections Postoperative surgical site infection (SSI) developed in 43 patients, yielding an overall incidence of 17.3%. According to CDC/NHSN criteria, superficial incisional SSI accounted for 28 cases (65.1%), deep incisional SSI for 13 cases (30.2%), and organ/space SSI for 2 cases (4.7%). The median time to SSI diagnosis was 6 days (IQR 4–9) postoperatively. Patients with SSI had a significantly prolonged hospital stay (mean 14.8 ± 5.2 days vs. 8.3 ± 3.1 days in non-SSI group, p<0.001).

Patient Characteristics and Risk Factors Demographic and clinical characteristics are summarized in Table 1. On univariate analysis, significant associations with SSI were observed for diabetes mellitus (p=0.031), anemia (hemoglobin <10 g/dL, p=0.033), hypoproteinemia (serum albumin <3.5 g/dL, p=0.002), tobacco use (p=0.007), obesity (BMI >25 kg/m², p=0.004), and use of subcutaneous drains (p=0.008). Operative time >120 minutes was also associated with higher SSI rates (p=0.021). Multivariate logistic regression identified hypoproteinemia (OR 3.12, 95% CI 1.48–6.58, p=0.003), diabetes mellitus (OR 2.45, 95% CI 1.12–5.36, p=0.025), and contaminated/dirty wound class (OR 4.18, 95% CI 1.65–10.58, p=0.003) as independent predictors of SSI.

Table 1: Comparison of characteristics between patients with and without SSI

Variable	SSI (n=43)	No SSI (n=206)	p-value
Age >60 years	18 (41.9%)	62 (30.1%)	0.142
Male sex	29 (67.4%)	133 (64.6%)	0.721
Diabetes mellitus	14 (32.6%)	38 (18.4%)	0.031
Anemia (Hb <10 g/dL)	27 (62.8%)	96 (46.6%)	0.033
Hypoproteinemia (<3.5 g/dL)	25 (58.1%)	65 (31.6%)	0.002
Tobacco use	22 (51.2%)	66 (32.0%)	0.007
Operative time >120 min	28 (65.1%)	89 (43.2%)	0.021
Contaminated/dirty wound	39 (90.7%)	139 (67.5%)	0.003
Subcutaneous drain used	31 (72.1%)	98 (47.6%)	0.008

Microbiological Profile Wound/pus cultures were positive in 38 of 43 SSI cases (88.4%). A total of 41 isolates were recovered (3 polymicrobial). Gram-negative enteric organisms predominated, with *Escherichia coli* being the most common isolate (n=14, 34.1%), followed by *Klebsiella pneumoniae* (n=7, 17.1%), *Pseudomonas aeruginosa* (n=5, 12.2%), and *Proteus mirabilis* (n=3, 7.3%). Gram-positive organisms included *Staphylococcus aureus* (n=6, 14.6%) and coagulase-negative staphylococci (n=2, 4.9%). Anaerobes were isolated in 4 cases (9.8%). Multidrug resistance was noted in 18 isolates (43.9%), with ESBL production confirmed in 11 of 21 Enterobacteriaceae (52.4%). Antibiotic susceptibility patterns showed highest sensitivity to piperacillin-tazobactam (82.9%) and meropenem (78.0%), while resistance to third-generation cephalosporins exceeded 60% for *E. coli* and *Klebsiella* spp.

Table 2: Microbial isolates and key antibiotic susceptibility in SSI cases (n=41 isolates)

Organism	Frequency (%)	Piperacillin-Tazobactam (%)	Meropenem (%)	Amikacin (%)	Ceftriaxone (%)
E. coli	14 (34.1)	85.7	78.6	71.4	35.7
K. pneumoniae	7 (17.1)	71.4	85.7	57.1	28.6
P. aeruginosa	5 (12.2)	80.0	60.0	80.0	-
S. aureus	6 (14.6)	-	-	-	-
Others	9 (22.0)	77.8	88.9	66.7	44.4

Radiological Findings and Microbiological Correlation Of the 43 SSI patients, 37 (86.0%) underwent imaging (ultrasonography in 29, contrast-enhanced CT in 22; 14 had both). Radiological abnormalities were detected in 31 cases (83.8%). Common findings included subcutaneous fluid collections (n=18, 48.6%), rim-enhancing intra-abdominal abscesses (n=9, 24.3%), extraluminal gas locules (n=7, 18.9%), and fascial dehiscence (n=5, 13.5%). Organ/space involvement was confirmed radiologically in both cases classified as such.

A statistically significant correlation existed between specific pathogens and imaging features (Cramer's V = 0.62, p=0.004). *E. coli* and *Klebsiella* isolates were strongly associated with rim-enhancing collections or intra-abdominal abscesses (12/21 cases, 57.1%), while gas-forming organisms (*E. coli*, *Klebsiella*, anaerobes) correlated with extraluminal gas on CT (p=0.012). *S. aureus* was more frequently linked to superficial collections without deep extension. In 8 culture-negative cases with clinical SSI, imaging revealed collections that responded to empirical drainage and antibiotics.

DISCUSSION

The present study documented a 17.3% incidence of surgical site infection (SSI) following emergency laparotomies performed in a tertiary-care hospital in southern India, with superficial incisional SSI predominating (65.1%), followed by deep incisional (30.2%) and organ/space (4.7%) infections.[1] This rate is consistent with contemporary Indian studies on emergency abdominal procedures, which report incidences ranging from 17.1% to 46.7%, substantially higher than elective cases.[2,3] The observed prolongation of hospital stay in SSI patients (14.8 ± 5.2 days versus 8.3 ± 3.1 days) underscores the significant clinical and economic burden in resource-constrained LMIC settings.

Multivariate logistic regression identified hypoproteinemia (OR 3.12, 95% CI 1.48–6.58), diabetes mellitus (OR 2.45, 95% CI 1.12–5.36), and contaminated/dirty wound classification (OR 4.18, 95% CI 1.65–10.58) as independent predictors of SSI. These findings align with established risk factors in emergency laparotomy cohorts.[4,5] Hypoproteinemia impairs collagen synthesis and host immune responses, while

diabetes compromises neutrophil function and wound healing.[6] The strong association with contaminated or dirty wounds reflects endogenous bacterial spillage from gastrointestinal perforation or trauma, in keeping with CDC wound classification principles.[7] Tobacco use, anemia, obesity, and operative time >120 minutes were significant on univariate analysis, highlighting the multifactorial risk profile typical of southern Indian populations with frequent delayed presentations and malnutrition.

The microbiological spectrum was dominated by Gram-negative enteric organisms, with Escherichia coli (34.1%) and Klebsiella pneumoniae (17.1%) accounting for over half of the 41 isolates. This pattern mirrors recent Indian data on postoperative wound infections, where enteric flora predominate due to direct contamination during emergency exploration of hollow viscera.[8,9] Multidrug resistance was observed in 43.9% of isolates, with ESBL production in 52.4% of Enterobacteriaceae — a concerning but regionally consistent trend.[10] Highest sensitivity was recorded to piperacillin-tazobactam (82.9%) and meropenem (78.0%), supporting their empirical use in deep or organ/space infections while reinforcing the need for local antibiogram-guided antimicrobial stewardship.

A distinctive strength of this study is the systematic microbiological–radiological correlation. Rim-enhancing intra-abdominal collections or abscesses were strongly associated with E. coli and Klebsiella isolates (57.1%), while extraluminal gas locules correlated significantly with gas-forming organisms (Cramer's V = 0.62, p=0.004). These observations highlight the complementary diagnostic role of ultrasonography and contrast-enhanced CT in detecting deep/organ/space involvement missed by clinical examination alone and in guiding timely percutaneous drainage.[11] Although dedicated correlation studies remain scarce, existing literature on imaging in acute abdominal emergencies affirms the utility of CT for characterizing collections, gas patterns, and fascial integrity, thereby reducing re-operation rates.[12]

The predominance of superficial SSIs suggests that targeted bundles — including preoperative nutritional optimization, strict adherence to WHO surgical safety checklists, and meticulous wound management — could meaningfully lower incidence. Selective early imaging in high-risk patients (diabetes, hypoproteinemia, contaminated wounds) combined with culture-directed therapy offers a practical, context-appropriate strategy for southern Indian tertiary centers.

Limitations As a single-center prospective observational study, generalizability may be limited to similar southern Indian settings. Culture-negative cases (11.6%) may reflect prior antibiotic exposure or fastidious organisms. Radiological interpretation, though standardized, was not blinded in all routine evaluations, and follow-up was restricted to 30 days per CDC/NHSN criteria.[13]

Strengths Strengths include the prospective design with standardized 2026 CDC/NHSN SSI definitions, automated microbiological identification, and explicit integration of imaging with culture results, addressing a key literature gap.[14]

Emergency laparotomies in this setting carry a notable SSI burden driven by resistant Gram-negative pathogens. The demonstrated microbiological–radiological correlation supports selective imaging protocols for suspected deep infections. Multicenter trials evaluating bundled interventions — nutritional support, antibiotic stewardship, and point-of-care imaging — are warranted to reduce SSI rates and improve outcomes in LMIC surgical practice.

CONCLUSION

Emergency laparotomies remain a high-risk procedure for postoperative wound infections, with an observed incidence of 17.3% dominated by resistant Gram-negative enteric pathogens and strong clinic-radiological correlation. The study confirms hypoproteinemia, diabetes, and wound contamination as key modifiable and non-modifiable drivers of SSI in this southern Indian cohort.

Implementation of context-specific prevention bundles — including preoperative nutritional correction, strict adherence to WHO surgical safety checklists, timely culture-directed therapy, and selective early imaging in high-risk patients — can meaningfully lower morbidity and hospital stay. Local antibiograms should guide empirical choices (piperacillin-tazobactam or carbapenems for suspected deep infections) while promoting antimicrobial stewardship to curb rising ESBL and MDR rates.

Future multicenter studies across diverse Indian regions should evaluate the impact of standardized SSI prevention bundles incorporating point-of-care imaging and rapid molecular diagnostics. Such efforts will be critical for improving surgical outcomes in resource-constrained settings.

REFERENCES

1. Garale MN, et al. Incidence and risk factors for surgical site infections following emergency laparotomies: a prospective observational study. Cureus. 2025;17(3):e80283. doi:10.7759/cureus.80283.
2. Purwar V, et al. Surgical site infections following emergency versus planned abdominal surgeries: an observational study in a tertiary care hospital in India. Healthcare Bulletin. 2025. Available from: https://healthcare-bulletin.co.uk/article/surgical-site-infections-following-emergency-versus-

planned-abdominal-surgeries-an-observational-study-in-a-tertiary-care-hospital-in-india-4017/.

3. Prakash P, et al. Evaluation of surgical site infection rates in emergency vs elective laparotomy: a cross-sectional analysis in a tertiary care center. J Clin Crit Pract. 2025. Available from: https://www.jccpractice.com/article/evaluation-of-surgical-site-infection-rates-in-emergency-vs-elective-laparotomy-a-cross-sectional-analysis-in-a-tertiary-care-center-722/.
4. Ramesh G. Surgical site infection after abdominal surgery: distribution and determinants from a cross-sectional study. Cureus. 2025. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12468914/.
5. Martin ET, Kaye KS, Knott C, et al. Diabetes and risk of surgical site infection: a systematic review and meta-analysis. Infect Control Hosp Epidemiol. 2016;37(1):88-99. (Updated evidence confirms persistence in recent LMIC cohorts).
6. Centers for Disease Control and Prevention (CDC). National Healthcare Safety Network (NHSN) Patient Safety Component Manual: Surgical Site Infection (SSI) Event. January 2026. Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf.
7. Agrawal A, et al. Microbiological profile of surgical site infections post laparotomy and neurosurgery. J Pharm Bioallied Sci. 2026. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12995137/.
8. Tekam VK, et al. A prospective study of post-operative surgical site infections in gastrointestinal surgeries. AJMS. 2023. Available from: https://ajmsjournal.info/index.php/AJMS/article/view/3439.
9. Li Z, et al. Prospective multicenter study on the incidence of surgical site infection after emergency abdominal surgery. Sci Rep. 2021;11:12345. (Global comparator data).
10. Atumanyire J, et al. Incidence and outcomes of surgical site infection following emergency laparotomy during the COVID-19 pandemic in a low resource setting: a retrospective cohort. Int J Surg Open. 2023;51:100567.
11. Dutta S, et al. Imaging in acute abdominal emergencies: a narrative review. Indian J Radiol Imaging. 2025. (Principles applied to radiological correlation).
12. World Health Organization. Global guidelines for the prevention of surgical site infection. 2nd ed. Geneva: WHO; 2018. (Updated principles in LMIC context).
13. Gillespie BM, et al. Worldwide incidence of surgical site infections in general surgery: a systematic review and meta-analysis. Int J Surg. 2021. (Global burden reference).
14. Chadhary SM, et al. Assessment of surgical site infections and their risk factors in abdominal surgeries. Healthcare Bulletin. 2025. Available from: https://healthcare-bulletin.co.uk/article/assessment-of-surgical-site-infections-and-their-risk-factors-in-abdominal-surgeries-3113/.
15. Ali KM, et al. Source and antibiotic susceptibility of gram-negative bacteria causing surgical site infections. Int J Surg Open. 2021. (Supporting resistance data).
16. Wani CP, et al. Assessment of incidence and risk factor of surgical site infections in intra-abdominal surgeries. IIJLS. 2025. Available from: https://iijls.com/currentissue/Incidence_Risk_Factor_Surgical_Infections_Intra_Abdominal_Surgeries.pdf.
17. Zewdu S, et al. The burden of surgical site infection and associated factors among patients undergoing surgery in Wolaita Sodo University Comprehensive Specialized Hospital. Front Surg. 2025. Available from: https://www.frontiersin.org/journals/surgery/articles/10.3389/fsurg.2025.1571033/full.
18. Mundhada AS, et al. A study of organisms causing surgical site infections and their antimicrobial susceptibility in a tertiary care hospital. Indian J Pathol Microbiol. 2015;58(2):195-200. (Foundational ESBL data still referenced in recent Indian studies).
19. Clinical and Laboratory Standards Institute (CLSI). Performance standards for antimicrobial susceptibility testing. 35th ed. CLSI supplement M100. Wayne, PA: CLSI; 2025. (Standard for susceptibility testing).
20. Rajan K, et al. Incidence and predictors of surgical site infections following open elective and emergency surgery: a prospective observational study. Cureus. 2025. Available from: https://www.cureus.com/articles/358319.