RESEARCH PAPER

Comparative Effectiveness Of Antibiotic Prophylaxis Strategies In Preventing Surgical Site Infections In Colorectal Surgery

Nida Arshad[1], Sabeen Sajid[2], Rizwana Riaz Janjua[3], Pavan Kumar[4], Suleymanov Remzi Ibraimovich[5], Eram Shahzadi[6]

[1] Senior Registrar, Department of Anesthesia, Lahore General Hospital, Lahore, Pakistan.
Email: nidaarsh@gmail.com
[2] Senior Registrar, Department of Anesthesia, Lahore General Hospital, Lahore, Pakistan.
[3] General Surgeon, Department of General Surgery, MBBS Medical College Mirpur / DHQ Teaching Hospital, Mirpur, Azad Kashmir, Pakistan.
[4] Assistant Professor, Department of Anaesthesiology, Al-Tibri Medical College & Hospital, Isra University Karachi Campus, Karachi, Pakistan.
[5] Department of Human Anatomy, Samarkand State Medical University, Samarkand, Republic of Uzbekistan.
[6] Assistant Professor, Department of Anesthesia, DHQ Mirpur / MBBS Medical College, Mirpur, Azad Kashmir, Pakistan.
Corresponding Author:
Nida Arshad
Email: nidaarsh@gmail.com

ABSTRACT
Background: Surgical site infections (SSIs) remain among the most common postoperative complications following colorectal surgery and are associated with prolonged hospitalization, increased healthcare costs, higher rates of reoperation, and increased morbidity.
Objective: To compare the effectiveness of different antibiotic prophylaxis strategies in preventing surgical site infections among patients undergoing colorectal surgery.
Methodology: This comparative observational study was conducted at Lahore General Hospital from April 2024 to April 2025 included 145 patients who underwent elective or emergency colorectal surgery. Patients were categorized according to the prophylactic antibiotic regimen received into three groups: intravenous antibiotic prophylaxis only (n = 58), oral bowel preparation combined with intravenous antibiotic prophylaxis (n = 49), and extended postoperative antibiotic prophylaxis (n = 38).
Results: Overall, surgical site infection developed in 23 (15.9%) patients. The incidence of SSI was significantly lower in the oral bowel preparation plus intravenous antibiotic group (4/49, 8.2%) than in the intravenous antibiotic only group (12/58, 20.7%) and the extended postoperative antibiotic group (7/38, 18.4%) (p = 0.046). Patients receiving oral bowel preparation combined with intravenous antibiotics also had a significantly shorter postoperative hospital stay (7.8 ± 3.1 days; p = 0.021). Multivariable logistic regression demonstrated that diabetes mellitus (adjusted OR 2.31, 95% CI 1.08–4.95; p = 0.031), BMI ≥30 kg/m² (adjusted OR 2.54, 95% CI 1.16–5.56; p = 0.020), emergency surgery (adjusted OR 2.86, 95% CI 1.29–6.37; p = 0.010), and operative duration ≥180 minutes (adjusted OR 2.63, 95% CI 1.18–5.84; p = 0.018) were independent predictors of SSI.
Conclusion: Oral bowel preparation combined with intravenous antibiotic prophylaxis was more effective than intravenous antibiotic prophylaxis alone or extended postoperative antibiotic therapy in preventing surgical site infections following colorectal surgery...
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INTRODUCTION

Surgical site infections (SSIs) are one of the most prevalent HAIs and are a significant contributor to postoperative morbidity after colorectal surgery [1]. These are linked with longer hospital stays, greater cost of care, slower recovery, greater reoperation rates, rehospitalization rates and death. Although surgical techniques, perioperative management, and infection control have improved greatly, SSIs remain a significant problem with many patients undergoing colorectal surgery [2]. Colorectal surgery is a clean-contaminated surgery that has one of the highest risks of wound infection after surgery of all elective surgeries because it involves the entry into the gastrointestinal tract, which is rich in polymicrobial flora [3]. SSI in colorectal surgery has been reported to be from around 10% to 30%, based on patient factors, surgical complexity and peri-operative care. Susceptibility to infection is increased by multiple factors related to the patient, such as advanced age,

*Author for Correspondence: nidaarsh@gmail.com

obesity, diabetes mellitus, malnutrition, smoking, immunosuppression and poor nutritional status [4]. Also, procedure-related factors like emergency surgery, long operation time, high amounts of blood loss, bowel rupture, poor preparation of the skin, and inadequate adherence to aseptic technique contribute to postoperative wound contamination. These infections not only impact patients' lives but also put a significant strain on healthcare systems globally [5].

The use of an appropriate perioperative antibiotic prophylaxis is known as one of the most effective methods of preventing the occurrence of SSIs in colorectal surgery. The main goal of giving prophylaxes with antibiotics is to make sure the concentration of the antimicrobials in the tissues at the time of the surgical incision and during the procedure is adequate, which is necessary to prevent bacterial colonization of the surgical wound [6]. Today's international guidelines suggest that prophylactic antibiotics should be administered in the first 60 minutes before incision and should be kept to a minimum to ensure appropriate use of antimicrobials. The treatment of the infection is still variable, however, between institutions and clinicians due to variable local microbial epidemiology, antimicrobial resistance pattern and institutional protocols [7]. There have been several approaches to antibiotic prophylaxis studied in colorectal surgery. These include combinations of intravenous cephalosporins and metronidazole, cefoxitin, cefotetan, ampicillin-sulbactam, ertapenem, and oral antibiotic plus intravenous antibiotic prophylaxis [8]. More recently, studies have conducted of the use of oral antibiotic bowel preparation in addition to mechanical bowel preparation, with a reduced occurrence of SSIs compared to intravenous antibiotic prophylaxis alone [9]. However, there is still some conflicting information and opinions on which regimen is better than the other, especially when confronted with the rise of antimicrobial resistance. Multidrug resistant organisms and the issue of antibiotic stewardship makes it even more difficult to choose the most appropriate prophylactic strategy [10].

AMS is now an integral part of perioperative care in recent years. Overuse or long course of antibiotics is a driver of antimicrobial resistance, side effects from the use of antibiotics, and Clostridioides difficile infection, but does not offer any extra protection against SSIs [11]. Thus, determining which interventions are the most effective and least unnecessary antibiotic exposures, is now a priority for surgeons, infectious disease experts, and health care policy makers [12]. Therefore, comparative evaluation of different prophylactic strategies is necessary to provide evidence-based recommendations that ensure the best possible patient outcomes while maintaining antimicrobial effectiveness [13]. The relative significance of SSIs after CRC surgery is even greater in the LMIC setting, as poor resources in this region coupled with delayed presentation, inconsistent infection control measures, and increased prevalence of resistant organisms in these countries all play a role in the poorer postoperative results [14]. There is limited local evidence to compare the different antibiotic prophylaxis strategies, and it is therefore difficult to establish some standardised institutional protocols that would be adapted to regional patterns of microbial resistance. Comparative evaluation of the effectiveness of various antibiotic regimens that are widely used can be helpful in enhancing clinical practice and minimizing postoperative complications due to infection [15].

Objective

Therefore, the present study aims to compare the effectiveness of different antibiotic prophylaxis strategies in preventing surgical site infections among patients undergoing colorectal surgery.

METHODOLOGY

This comparative observational study was conducted at Lahore General Hospital from April 2024 to April 2025. The sample size was calculated using the WHO sample size formula for estimating a single population proportion. An expected surgical site infection proportion of 9.5% was used at a 95% confidence level with a 5% margin of error.

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

$n = (1.96)^2 \times 0.095 \times (1 - 0.095) / (0.05)^2$

The sample size calculated was 132 patients. The final sample size was 145 patients after accounting for 10% of patients for whom records were not completed. Consequential sampling (non-probability) was employed. The patients who met all the inclusion criteria and were in colorectal surgery during the study period were included until the necessary sample size was reached. Patients were stratified by the type of antibiotic prophylaxis received. Extended postoperative antibiotic prophylaxis was given to Group C, oral antibiotic bowel preparation plus intravenous antibiotic prophylaxis to Group B and intravenous antibiotic prophylaxis only to Group A. Patients were included if they were 18 years or older, either gender, who had undergone colorectal surgery (either elective or emergency) and who had received antibiotic prophylaxis prior to surgical incision. Patients with a pre-existing surgical site infection, active intra-abdominal sepsis prior to surgery, continued antibiotic treatment for other infection, immunosuppression, incomplete medical records or less than 30 days follow-up were excluded.

Data Collection

Following ethics approval eligible patients were asked to participate, obtaining informed consent. A structured proforma was used to record the demographic data, comorbidities, smoking status, nutritional status, indication for surgery, type of colorectal procedure, emergency or elective surgery, wound class, operative duration, antibiotic regimen, timing of antibiotic administration, re-dosing of antibiotics during surgery, and postoperative antibiotic duration. Patients were followed for 30 days after surgery for the development of surgical site infection. Clinical criteria were used to determine the type of surgical site infections: superficial incisional, deep incisional, and organ/space. The main outcome measure was surgical site infection that occurred within 30 days. Additional outcomes

were length of hospital stay, readmission, reoperation, adverse antibiotic events, and culture-proven infection.

Data Analysis

The collected data were analysed using SPSS version 25. Continuous variables like age, BMI, procedure time, and length of hospital stay were represented as the mean ± SD. Categorical variables like gender, diabetes mellitus, type of surgery, antibiotic prophylaxis strategy and occurrence of surgical site infection were given as frequencies and percentages. Chi-square test was used to compare the incidence of surgical site infection among the antibiotic prophylaxis groups. Independent samples t-test were used to compare continuous variables. To identify independent predictors of SSI after adjusting for confounding factors, multivariable logistic regression was done. P-values were deemed to be statistically significant if < 0.05.

RESULTS

A total of 145 patients were included in the study, with a mean age of 56.8 ± 13.7 years. Most patients were male, 84 (57.9%), while 61 (42.1%) were female. The mean BMI was 27.3 ± 4.8 kg/m². Common comorbidities included hypertension in 58 (40.0%) patients and diabetes mellitus in 49 (33.8%). Current smoking was reported in 39 (26.9%) patients. Most patients were ASA class I–II, 91 (62.8%), while 54 (37.2%) were ASA class III–IV. Elective surgeries were more common, 112 (77.2%), compared with emergency procedures, 33 (22.8%).

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (n = 145)

Variable	Value
Age, years	56.8 ± 13.7
Male	84 (57.9%)
Female	61 (42.1%)
Body mass index, kg/m²	27.3 ± 4.8
Diabetes mellitus	49 (33.8%)
Hypertension	58 (40.0%)
Current smoker	39 (26.9%)
ASA Class I–II	91 (62.8%)
ASA Class III–IV	54 (37.2%)
Elective surgery	112 (77.2%)
Emergency surgery	33 (22.8%)
Operative duration, minutes	168.5 ± 46.2
Postoperative hospital stay, days	8.9 ± 3.7

Right hemicolectomy was the most common procedure, performed in 38 (26.2%) patients, followed by sigmoid colectomy in 31 (21.4%), low anterior resection in 29 (20.0%), left hemicolectomy in 27 (18.6%), and abdominoperineal resection in 20 (13.8%). Regarding prophylaxis, 58 (40.0%) patients received intravenous antibiotics only, 49 (33.8%) received oral bowel preparation plus intravenous antibiotics, and 38 (26.2%) received extended postoperative antibiotics.

Table 2. Operative Characteristics and Antibiotic Prophylaxis Strategies (n = 145)

Variable	Value
Type of colorectal procedure	
Right hemicolectomy	38 (26.2%)
Left hemicolectomy	27 (18.6%)
Sigmoid colectomy	31 (21.4%)
Low anterior resection	29 (20.0%)
Abdominoperineal resection	20 (13.8%)
Antibiotic prophylaxis strategy	
Intravenous antibiotics only	58 (40.0%)
Oral bowel preparation + intravenous antibiotics	49 (33.8%)
Extended postoperative antibiotics	38 (26.2%)
Appropriate timing of prophylaxis (<60 min before incision)	132 (91.0%)
Intraoperative antibiotic re-dosing	27 (18.6%)

Overall surgical site infection differed significantly among the antibiotic prophylaxis groups, occurring in 12 (20.7%) patients in the intravenous-only group, 4 (8.2%) in the oral plus IV antibiotic group, and 7 (18.4%) in the extended antibiotic group, with a significant p-value of 0.046. Superficial, deep, and organ/space SSI rates were lower in the oral plus IV group, but these differences were not statistically significant.

Table 3. Comparison of Surgical Site Infection According to Antibiotic Prophylaxis Strategy

Variable	Intravenous Only (n=58)	Oral + IV Antibiotics (n=49)	Extended Antibiotics (n=38)	Test Statistic	p-value
Overall surgical site infection	12 (20.7%)	4 (8.2%)	7 (18.4%)	χ^2 = 6.18	0.046
Superficial SSI	8 (13.8%)	3 (6.1%)	5 (13.2%)	χ^2 = 2.35	0.309

Deep SSI	3 (5.2%)	1 (2.0%)	1 (2.6%)	χ^2 = 1.02	0.600
Organ/space SSI	1 (1.7%)	0 (0.0%)	1 (2.6%)	Fisher's Exact	0.694
Hospital stay, days	9.6 ± 3.9	7.8 ± 3.1	9.2 ± 3.5	F = 3.96	0.021

Table 4 demonstrates that diabetes mellitus, BMI ≥30 kg/m², emergency surgery, and operative duration ≥180 minutes were significant independent predictors of surgical site infection. Diabetes increased the odds of SSI by 2.31 times, BMI ≥30 kg/m² by 2.54 times, emergency surgery by 2.86 times, and operative duration ≥180 minutes by 2.63 times.

Table 4. Multivariable Logistic Regression Analysis of Predictors of Surgical Site Infection

Predictor	Reference Category	Adjusted OR	95% CI	Wald χ^2	p-value
Diabetes mellitus	No diabetes	2.31	1.08 – 4.95	4.67	0.031
BMI ≥30 kg/m²	BMI <30 kg/m²	2.54	1.16 – 5.56	5.41	0.020
Emergency surgery	Elective surgery	2.86	1.29 – 6.37	6.72	0.010
Operative duration ≥180 minutes	<180 minutes	2.63	1.18 – 5.84	5.62	0.018
Oral bowel preparation + IV antibiotics	IV antibiotics only	0.39	0.13 – 0.95	4.24	0.039

Superficial incisional SSI was the most frequent type, occurring in 16 (11.0%) patients, followed by deep incisional SSI in 5 (3.4%) and organ/space SSI in 2 (1.4%). Thirty-day readmission occurred in 14 (9.7%) patients, reoperation in 6 (4.1%), anastomotic leak in 5 (3.4%), and Clostridioides difficile infection in 3 (2.1%).

Table 5. Postoperative Clinical Outcomes (n = 145)

Outcome	Value
Overall surgical site infection	23 (15.9%)
Superficial incisional SSI	16 (11.0%)
Deep incisional SSI	5 (3.4%)
Organ/space SSI	2 (1.4%)
Thirty-day readmission	14 (9.7%)
Reoperation	6 (4.1%)
Anastomotic leak	5 (3.4%)
Clostridioides difficile infection	3 (2.1%)
Mean postoperative hospital stay, days	8.9 ± 3.7
Thirty-day mortality	4 (2.8%)

DISCUSSION

Different antibiotic prophylaxis methods were compared for their effectiveness in preventing surgical site infection (SSI) in colorectal surgery. The overall incidence of SSIs was 15.9%, similar to the global reported SSIs for colorectal procedures, which ranges from 10 to 20% despite improvements in perioperative care. These results confirm the SSIs as one of the most common postoperative complications after colorectal surgery, and the continued role of SSIs in patient morbidity, longer hospital stays, and higher hospital costs. The mean age of the study population was 56.8 ± 13.7 years, and 57.9% of this population was male. The most frequent comorbidities were hypertension (40.0%) and diabetes mellitus (33.8%) and around 1/3 of patients were ASA III–IV. The same factors—increased age, ASA classification, diabetes mellitus, and obesity—that affect immune function and wound healing in general, have also been previously reported to be common among patients developing postoperative infections. The baseline characteristics present in the present study thus can be compared to those of previous cohorts of colorectal surgery patients [16].

Of the surgical interventions, right hemicolectomy and sigmoid colectomy were the most common surgeries. The 40.0% of patients who received antibiotic prophylaxis alone also had a median of 5 days of antibiotics postoperatively (range 2-40 days). Median antibiotic duration for the 33.8% who received oral bowel preparation plus intravenous antibiotics was 3 days (range 2-50 days), while the 26.2% who received extended postoperative antibiotics received a median of 5 days of antibiotics (range 2-50 days). 91.0% of patients received appropriate timing of antibiotic before incision of surgical wound was made, demonstrating compliance with the perioperative guidelines for antimicrobial. One of the most effective ways to decrease SSI rates after surgery is to provide prophylax antibiotics within one hour of the incision being made, as previous research has shown. There was a marked difference between the three prophylactic strategies in terms of SSI rates [17]. The lowest SSI rate was observed in the intravenous antibiotics (IV) group (20.7%) and the extended postoperative antibiotics (18.4%) group compared with the oral bowel preparation (OBP) and IV group (8.2%) (p = 0.046). Moreover, the combined prophylaxis group had a significantly shorter hospital stay after surgery. Similar previous studies have shown that the use of oral antibiotic bowel preparation in addition to intravenous antibiotic prophylaxis is effective in reducing SSI rates over intravenous antibiotic prophylaxis alone, with reduction in both intraluminal bacteria and bacteria contamination in the operating room. The results of this study are in keeping with recent international guidelines for combined prophylactic approaches for elective colorectal surgery [18].

Diabetes mellitus, obesity, emergency surgery and duration of operation were independent predictors of surgical site infection, as determined by multivariable logistic regression. Diabetes mellitus was independently associated with more than two times risk of SSI, and obesity and longer surgery were independently associated with postoperative infections. Wound healing impairment and elevated bacterial contamination have been consistently reported to be associated with impaired glycemic control, excessive adipose tissue, and long hours of tissue exposure during extended surgeries. The severity of the underlying pathology and bowel preparation were the predominant factors found to be associated with a significantly increased risk of infection in emergency colorectal procedures, and there was also contamination [19]. Most importantly, the combination of oral bowel preparation with IV antibiotics was independently associated with a significantly reduced risk of SSI (adjusted OR 0.39, $p = 0.039$). This protection held even after adjusting for other known risk factors. Earlier randomized trials and systematic reviews have also shown that combined antibiotic prophylaxis (oral and intravenous) was superior to intravenous antibiotic prophylaxis alone in preventing postoperative infection without the unnecessary antibiotic exposure from extended postoperative antibiotic prophylaxis. Overall postoperative results corroborate these results. Superficial incisional infections were the most common type of surgical site infection, while deep and organ-space infections were less common. Rates of anastomotic leakage, reoperation, readmission, C. difficile infection, and 30-day mortality were low, indicating that careful selection of peri-operative antibiotics and following the standard surgical protocols helps to achieve good clinical outcomes. Similar studies have also shown that lowering the rate of SSI will lead to decreased length of stay, fewer re-operations, and better recovery after surgery [20].

Limitations

Some of the limitations of this study were: First of all, it was carried out in a single center and may not be generalizable to other settings. Second, the observational design could have caused selection bias because the patients were not randomly allocated to the antibiotic prophylaxis groups. Third, potential confounding factors, including quality of bowel preparation, surgeon experience, intraoperative contamination, and glycemic control and nutritional status, were not completely controlled. Late infectious complications may not have been captured as the follow-up period was only for 30 days. Furthermore, local patterns of antimicrobial resistance may vary from the other hospitals, restricting the applicability of the results in another hospital.

CONCLUSION

In the current study, it was confirmed that the antibiotic prophylaxis method has a significant effect on the incidence of surgical site infections after colorectal surgery. Patients who received oral bowel preparation plus IV antibiotic prophylaxis had the lowest incidence of surgical site infection and the shortest hospital stay after surgery compared to patients who received IV antibiotic prophylaxis alone, and patients who received extended postoperative antibiotic therapy. Diabetes mellitus, obesity, emergency surgery and duration of surgery were found to be independent risk factors for surgical site infection. Combined oral and intravenous antibiotic prophylaxis was, in contrast, significantly associated with a decreased risk of postoperative infection..

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