e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.11.97

International Journal of Pharmaceutical Quality Assurance 2025; 16(11); 625-630

Original Research Article

A Retrospective Evaluation of Surgical Antimicrobial Prophylaxis: Assessment of Antibiotic Selection, Timing of Administration and Re-dosing Practices

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Received: 12-10-2025 / Revised: 10-11-2025 / Accepted: 29-11-2025

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Conflict of interest: Nil

Abstract:

Background: Surgical site infections (SSIs) are common healthcare-associated complications that increase morbidity, hospital stay, and cost. Surgical antimicrobial prophylaxis (SAP) reduces infection risk, but inappropriate selection, timing, duration, and re-dosing promote antimicrobial resistance.

Aim: To evaluate antibiotic selection, timing of administration, duration, and intra-operative re-dosing practices of SAP and their association with SSIs.

Methodology: A six-month retrospective observational study reviewed 136 elective clean and clean-contaminated surgeries. Data from medical and operative records were assessed against standard guidelines using descriptive and comparative statistical analysis.

Results: Cephalosporins predominated (ceftriaxone 42.6%). Appropriate timing within 60 minutes occurred in 63.2% of cases, appropriate duration (≤24 h) in 45.6%, and correct re-dosing in 33.3% of eligible cases. Overall guideline compliance was 42.6%. SSI incidence was 10.3%. Infection occurred in 5.17% of compliant and 14.1% of non-compliant cases (RR=0.37, p>0.05).

Conclusion: SAP practices showed partial adherence, with prolonged duration and inadequate re-dosing as major deviations. Although compliance reduced SSI risk, the association was not statistically significant. Strengthened antimicrobial stewardship and standardized protocols are needed to improve rational prophylaxis.

Keywords: Surgical antimicrobial prophylaxis, surgical site infection, antibiotic stewardship, timing of administration, prophylaxis duration, re-dosing.

Introduction

Surgical Site Infections (SSIs) are among the most common and serious problems that are related to operation across the globe. They are regarded as the most prevalent type of healthcare-associated infections, they are estimated to cause almost half a million nosocomial infections every year that leads to a greater healthcare cost of nearly 2 billion. The incidence of SSIs in 30 days of operation causes the consumption of more antibiotics, long hospitalization, supplementary procedures, and higher costs of treatment. Prophylactic antibiotics are thus very important in the prevention of postoperative wound infections. Nevertheless, the overuse or misuse of antibiotics leads to the amplification of selective pressure in support of the development of resistance among microbes. Therefore, the use of antibiotics in hospitals requires careful and rational use [1] that should be monitored.

The surgical antimicrobial prophylaxis (SAP) is mainly prescribed in the case of clean and clean-contaminated wounds. To get the best benefits, standard guidelines focus on four significant elements, which are proper selection of antibiotics, proper timing of taking the medication, proper duration of treatment, as well as proper re-dosing. Cephalosporins are preferred in patients who have clean-contaminated surgeries including cardiothoracic, gastrointestinal, orthopedic, vascular and gynecologic surgeries as prophylactic agents [2]. In most of the operations, preoperative dose is adequate. The maximum time of prophylaxis is 48 hours except in some special surgeries like the prostate and the intravenous route is the best way of administration.

Prophylaxis depends on timing of administration as a major factor. The concept of SAP is that the concentration of the antibiotic are supposed to be at the peak when incision is made. As such, timing is different according to the pharmacokinetic profile of the chosen antimicrobial agent. Literature has indicated that proper antimicrobial prophylaxis before surgery can prevent SSIs by close to half. Antibiotics in the event that they are applied too early or too late reduce their effectiveness, which consequently raises the risk of postoperative infection [3].

Based on recent surveys done by the international health agencies, the incidence of nosocomial infections is between 3 and 21%. The SSI rates in the world are estimated to be between 0.5 and 15 per cent, but in India, the rate is between 25-38 per cent. The causes of SSIs are varied and they can be explained as follows: poor hygiene of the operating theatres, improper sterilization, poor pre-operative preparation, and inadequate after-operative care as well as the type of surgery performed [4].

In developed nations, SSIs are the cause of 14%16% of about two million healthcare-associated infections whereby the infection rate in developed nations is reported to be approximately 1.9. They happen in 2-5 percent of patients that undergo clean extra-abdominal surgeries and 20 percent of patients that are going through intra-abdominal surgeries. Other than clinical complications, SSIs present a huge economic burden. Out of pocket payments in India are almost 72 percent of the healthcare bills, and other costs, covering the treatment of SSI, longer hospital stay, repeat operation, and lost working ability, result in a huge burden on the patients and their families [5].

Almost a third of surgical site infections can be avoided by taking preventive measures that are adopted during the pre-operative, intra-operative, and post-operative stages. Surgical antimicrobial prophylaxis is the use of short course of antimicrobial therapy before surgical operation to avoid microbial contamination of the surgical wound. This has been identified to be an effective preventive measure during the pre-operative stage. Correct SAP minimizes the chances of developing severe complications like sepsis, organ failure and death during hospitalization [6].

Irrelevant antibiotic choice, inadequate administration, excessive time, and re-dosing are still frequent issues in clinical practice even though there are well-established recommendations. Excessive or inappropriate use of antibiotics does not only not stop infections but also encourages antimicrobial resistance which has become a significant world health problem. Hence, it is important to monitor and evaluate antibiotic prophylaxis practices continuously to achieve positive patient outcomes and decrease resistance patterns.

Evaluation of existing SAP practices would give an idea about the compliance with the guidelines and allow detecting gaps in clinical implementation. Particularly, retrospective studies provide valuable information about prescribing trends, rational drug use, and adherence to the recommended practices. Healthcare institutions can build specific antimicrobial stewardship strategies and enhance the quality of care in surgery by examining antibiotic choice, time of administration, length of therapy and re-dosing.

The morbidity and mortality of SSIs with its financial implications highlight the importance of the need to adhere to the prophylaxis of antibiotics strictly. The knowledge of prescribing trends also contributes to the maximization of antibiotic use, reduced resistance development, and improved patient safety. Moreover, proper prophylaxis helps in lowering hospitalization, post-operative complications, and better post-operative surgery.

Based on these facts, it is evident that there is a necessity to review the existing practice of surgical antimicrobial prophylaxis. An assessment of the rationality of using antibiotics and based on the recommended guidelines can be developed through a retrospective assessment. This kind of analysis is very crucial not only in prevention of surgical site infections but also in curbing antimicrobial resistance and in general enhancing patient care.

Methodology

Study Design: This study was conducted as a hospital-based retrospective observational study aimed at evaluating the rationality of surgical antimicrobial prophylaxis with respect to antibiotic selection, timing of administration, duration of therapy, and intra-operative re-dosing practices. The study involved analysis of previously recorded patient data without any direct patient intervention.

Study Area: The study was carried out in the Department of Pharmacology, Darbhanga Medical College and Hospital (DMCH), Laheriasarai, Darbhanga, Bihar, India.

Study Duration: The study was conducted over a period of 7 months from March 2025 to September 2025.

Sample Size: A total of 136 surgical cases fulfilling the eligibility criteria were included in the study. Only complete and accessible medical records were considered for analysis.

Study Population: The study population consisted of patients of both genders and all age groups who underwent elective surgical procedures in the operation theatres of Darbhanga Medical College and Hospital and received antimicrobial prophylaxis. Patients were selected based on predefined inclusion and exclusion criteria.

Data Collection: Data were collected retrospectively from operation theatre registers, patient case sheets, anesthesia notes, medication administration charts, and postoperative treatment records. A structured data collection form was used to record demographic details such as age and gender, type of surgery, wound classification, antibiotic prescribed, dose and route of administration, timing of antibiotic administration before surgical incision, intra-operative re-dosing, and duration of postoperative antibiotic therapy. The collected data were compiled and entered into Microsoft Excel for organization and further analysis.

Inclusion Criteria

- Patients of both genders and all age groups
- Patients undergoing elective surgical procedures
- Clean and clean-contaminated surgeries
- Patients who received surgical antimicrobial prophylaxis

Exclusion Criteria

- Contaminated and dirty-infected surgeries
- Emergency surgeries with therapeutic antibiotic use
- Patients with incomplete medical records
- Patients already on antibiotics for active infection before surgery

Study Procedure: After obtaining ethical clearance and permission from hospital authorities, medical records of surgical patients during the six-month study period were screened. A total of 136 eligible cases meeting the inclusion criteria were selected. Relevant data regarding antimicrobial prophylaxis were extracted using a standardized data collection form. The appropriateness of antimicrobial prophylaxis was assessed based on standard surgical antimicrobial prophylaxis guidelines such as WHO, CDC, and ASHP recommendations, including evaluation of antibiotic selection, timing of administration prior to incision, requirement of intra-operative re-dosing, and duration of prophylaxis after surgery. The extracted data were systematically compiled and tabulated for analysis.

Statistical Analysis: The collected data were analyzed using statistical software such as SPSS and Microsoft Excel. Descriptive statistics including mean, standard deviation, frequency, and percentage were used to summarize the variables. Parametric data were analyzed using Student's t-test or Z-test, while categorical variables were compared using Chi-square test or Fisher's exact test. A p-value less than 0.05 was considered statistically significant."

Result

Table 1 presents the demographic and surgical characteristics of 136 patients. Most were male (88, 64.7%), while 48 (35.3%) were female. The largest age group was 21–40 years (54, 39.7%), followed by 41–60 years (46, 33.8%), >60 years (24, 17.6%), and <20 years (12, 8.8%). By department, General Surgery accounted for the majority (76, 55.9%), followed by Orthopedics (24, 17.6%), Obstetrics & Gynecology (18, 13.2%), ENT (12, 8.8%), and Urology (6, 4.4%). Most procedures were clean surgeries (92, 67.6%), while 44 (32.4%) were clean-contaminated.

Table 1: Demographic and Surgical Characteristics of Study Population (N = 136)

Variable	Category	Number (n)	Percentage (%)
Gender	Male	88	64.7
	Female	48	35.3
Age Group (years)	<20	12	8.8
	21–40	54	39.7
	41–60	46	33.8
	>60	24	17.6
Department	General Surgery	76	55.9
	Orthopedics	24	17.6
	Obstetrics & Gynecology	18	13.2
	ENT	12	8.8
	Urology	6	4.4
Type of Surgery	Clean	92	67.6
	Clean-Contaminated	44	32.4

Table 2 shows the pattern of surgical antimicrobial prophylaxis antibiotic selection among 136 patients. Cephalosporins were the most commonly used class, particularly ceftriaxone (58, 42.6%), followed by cefotaxime (28, 20.6%) and cefazolin (14, 10.3%). Other agents included piperacillin–tazobactam (16, 11.8%), metronidazole combinations (12, 8.8%), and amikacin/ciprofloxacin (8, 5.9%). Overall, third-generation cephalosporins predominated in prophylactic use.

Table 2: Pattern of Surgical Antimicrobial Prophylaxis — Antibiotic Selection (N = 136)			
Antibiotic Class	**Drug**	**Number (n)**	**Percentage (%)**
Cephalosporins	Ceftriaxone	58	42.6
	Cefotaxime	28	20.6
	Cefazolin	14	10.3
Penicillin + β-lactamase inhibitor	Piperacillin-Tazobactam	16	11.8
Nitroimidazole combination	Metronidazole combinations	12	8.8
Others	Amikacin / Ciprofloxacin	8	5.9
Total		**136**	**100**

Table 3 evaluates the appropriateness of timing, duration, and re-dosing of surgical antimicrobial prophylaxis among 136 patients. Prophylaxis was administered within 60 minutes before incision in 86 patients (63.2%), considered appropriate, while 18 (13.2%) received it >60 minutes before and 32 (23.5%) after incision, both inappropriate. Regarding duration, only 62 patients (45.6%) received prophylaxis for ≤24 hours (appropriate), whereas 48 (35.3%) had prolonged use (24–72 hours) and 26 (19.1%) highly prolonged use (>72 hours). Among 18 patients (13.2%) eligible for re-dosing, only 6 (4.4%) received it appropriately, while 12 (8.8%) did not, indicating gaps in adherence to prophylaxis guidelines.

Table 3: Appropriateness of Timing, Duration and Re-dosing of Prophylaxis				
Parameter	**Category**	**Number (n)**	**Percentage (%)**	**Guideline Status**
Timing before incision	Within 60 min	86	63.2	Appropriate
	>60 min before	18	13.2	Inappropriate
	After incision	32	23.5	Inappropriate
Duration of prophylaxis	≤24 hours	62	45.6	Appropriate
	24–72 hours	48	35.3	Prolonged
	>72 hours	26	19.1	Highly prolonged
Eligible for re-dosing	Yes	18	13.2	—
	Received re-dosing	6	4.4	Appropriate
	Not received	12	8.8	Inappropriate

Table 4 shows overall compliance with surgical antimicrobial prophylaxis among 136 patients. Appropriate antibiotic selection was observed in 82 cases (60.3%), and correct timing in 86 cases (63.2%). However, compliance was lower for duration (62, 45.6%) and particularly poor for re-dosing in eligible cases (6, 33.3%). Overall, only 58 patients (42.6%) received fully appropriate prophylaxis, while 78 (57.4%) had inappropriate practices, indicating suboptimal adherence to recommended guidelines.

Table 4: Overall Compliance with Surgical Antimicrobial Prophylaxis (N = 136)		
Parameter	**Appropriate n (%)**	**Inappropriate n (%)**
Antibiotic selection	82 (60.3)	54 (39.7)
Timing	86 (63.2)	50 (36.8)
Duration	62 (45.6)	74 (54.4)
Re-dosing (eligible cases)	6 (33.3%)	12 (66.7%)
Overall compliance	**58 (42.6)**	**78 (57.4)**

Table 5 presents the surgical site infection (SSI) rate among 136 patients. SSI occurred in 14 patients (10.3%), while 122 patients (89.7%) had no infection, indicating that the majority of patients did not develop postoperative infection.

Table 5: Surgical Site Infection Rate (N = 136)		
SSI Status	**Number (n)**	**Percentage (%)**
SSI Present	14	10.3
No SSI	122	89.7

Table 6 shows the association between compliance and surgical site infection (SSI) among 136 patients. In the compliant group (n=58), 3 patients developed SSI (5.17%) while 55 had no infection. In contrast, the non-compliant group (n=78) had 11 SSI cases (14.1%) and 67 without SSI. Although the calculated relative risk (RR = 0.37) suggests a lower risk of infection with compliance, the p-value >0.05 indicates that this difference was not statistically significant.

Table 6: Association Between Compliance and Surgical Site Infection				
Compliance	**SSI Present**	**No SSI**	**Total**	**Risk (%)**
Compliant	3	55	58	5.17
Non-compliant	11	67	78	14.1
Total	**14**	**122**	**136**	

Note: Relative Risk (RR) = 0.37
P-value > 0.05 (Not statistically significant)

Discussion

The current retrospective analysis revealed that only 42.6% of surgical antimicrobial prophylaxis (SAP) adherence to the recommended practice was achieved, and therefore, over fifty percent of the prescriptions were not consistent with the recommended practice. Lack of compliance in our group was mainly associated with the long period of time, improper timing, and failure to re-dose during the surgery. Indian tertiary care settings have reported similar trends of low compliance with 20-40% compliance observed, and reporting persistent implementation gaps (Jaggi et al., 2018) [7]. By contrast, in developed healthcare systems, institutional protocols enforced by structured antimicrobial stewardship programs have reported adherence of over 70% indicating that institutional protocol enforcement plays a significant role in influencing prescribing behavior (Lerano et al., 2017) [1]. The distinction suggests that inappropriate prophylaxis is significantly contributed by local practice of prescribing and lack of surveillance."

The antibiotics selected in our research were highly dominated by the third generation cephalosporins, especially ceftriaxone (42.6%), cefotaxime (20.6%) with cefazolin being only 10.3. The trend is in line with the results of Sharma and Goel (2018) who found that third-generation cephalosporins were prescribed 61 percent and 20.5 percent on piperacillin-tazobactam, respectively [8]. International guidelines however recommend first generation cephalosporins like cefazolin as the first line of choice in most clean surgeries because it is narrow in spectrum and has reduced risk of resistance (Nicholas, 2005) [5]. Raising the rate of broader-spectrum agent usage among our population, then, is irrational escalation, which can foster antimicrobial resistance and Clostridioides difficile infection as highlighted by Balch et al. (2017) [4]. Afzal et al. (2013) also found the high-end antibiotics were commonly used even when there was no indication of it, indicating a steady tendency toward over-coverage in the developing countries [9].

On timing, there was only 63.2% prophylaxis administered to patients within 60 minutes even before incision and 23.5% administered antibiotics after incision. Richman et al. have already used an optimum of 28 minutes pre-incision administration and have shown increased incidences of surgical site infection (SSI) with increased administration past 60 minutes. Our results align with this observation as 14.1 per cent cases of non-compliant infection versus 5.17 per cent compliant infection resulted in occurrence of infection almost threefold even when there was no statistical significance. The same linkage has been demonstrated in prospective research studies in which the improper timing intensified the chances of SSI (Najjar and Smink, 2017) [3]. Delays in administration in our hospital is hence a preventable source of infection.

The worst parameter to include in the analysis was duration of prophylaxis where there were only 45.6% who received antibiotics for 24 hours and 54.4% who received antibiotics longer than prescribed limits. According to Sharma and Goel (2018), the average time was even more extended to 8.23 days [8], which proves that longer prophylaxis is still in use. It has always been shown that there is no extra benefit after 24 hours but more side effects and resistance (Cohen, 2017) [6]. Leuva et al. (2014) have also indicated that the prophylaxis of clean surgeries was not found to be shorter than the prophylaxis of single-dose regimens in terms of infection reduction [10]. Hence, the prevalence of extended administration in our study, which is high, may not only be unnecessary but even harmful.

Our results were especially poor in intra-operative re-dosing compliance as merely 33.3% of results eligible patients were re-dosed. Like under-utilization is also observed in orthopedic units where adherence to re-dose was less than 25% (Argaw et al., 2017) [11]. It implies that surgeons might be more focused on continuation in the postoperative than on therapeutic intra-operative levels, despite the importance of pharmacokinetic principles on the latter. According to Kashyap (2018), re-dosing is necessary during the extended interventions or blood loss so that bactericidal levels are preserved [2]. Lapse of re-dosing may thus be the explanation of infections despite long-term postoperative treatment.

The total SSI rate of our research was 10.3%. This falls in between values in Indian literature (623%), based on wound class (Sankaran et al., 2016) [12]. Rehan and Kakkar (2010) showed that clean surgeries had an SSI rate of 3.03% and clean-contaminated operations had 22.4% which is similar to our results that infections were more common in clean-contaminated operations [13]. Our cases also concur with the epidemiological known literature regarding post-operative wound infections in that Staphylococcus aureus is predominantly isolated (Nicholas, 2005) [5]. Further, the protective effect of guideline adherence is justified by the relative risk of 0.37 in our study though there was no statistical significance because of the small sample size.

Interestingly, although non-compliance was high, the difference of infection in compliant and non-compliant groups was not significant. Similar results were also described by Karlatti and Havannava (2016), who also found that SSI reduction was lower, but statistically insignificant with optimized prophylaxis [14] practices. This could be explained by multifactorial determinants of SSI like surgical procedure, asepsis, and other comorbid conditions of the patient besides antibiotics usage. However, this numerical decrease is clinically significant and consistent with prevention benefit in the systematic reviews (Najjar and Smink, 2017) [3].

Comprehensively, it can be seen that the lack of appropriate antibiotic selection, and the extended course of treatment are still the issues of global concern, and the lack of timeliness and re-dose is the gap in the institutional practice, as revealed through comparison with past literature. The necessity of antimicrobial stewardship programs and standardization of perioperative protocols, as well as ongoing audit feedback, reinforce our results in enhancing overall adherence and slowing down the development of resistance.

Conclusion

This retrospective analysis revealed that although surgical antimicrobial prophylaxis was widely used across the departments and much of the use of cephalosporin-based regimens was in predominantly clean and clean-contaminated surgery, compliance with the recommended guidelines was poor. The choice and time of administration of antibiotics was correct in most instances, but the administration before or after the suggested window was still incorrect. The commonest guideline deviation was the long-term use of antibiotics after surgery, as well as under-re-dosing in surgeries that were eligible, which lead to low general compliance. Even though the cases of surgical site infection were more frequent in non-compliant cases, there was no significant association. The results support the idea that antimicrobial stewardship interventions, as well as standardized guidelines and clinician awareness, should be increased to enhance rational prophylaxis practices and reduce the number of unnecessary antibiotic exposures.

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