A Comprehensive Study on Antibiotic Prophylaxis Practices Across Diverse Surgical Modalities

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Abstract

Background: Surgical antimicrobial prophylaxis (SAP) is critical for preventing surgical site infections (SSIs). However, inappropriate use of SAP contributes to antibiotic resistance. This study evaluated compliance with the American Society of Health-System Pharmacists (ASHP) SAP guidelines at a tertiary care hospital in India and assessed the implications for SSI prevention and antimicrobial stewardship.

Methods: A prospective observational study was conducted from June–August 2024, analyzing 95 surgical cases. SAP practices were audited against the ASHP guidelines for five parameters: indication, antibiotic choice, timing (pre-incision 30–60 min), route (IV), and duration (< 24h postoperatively). Data were collected systematically from electronic records and analyzed for compliance rates.

Results: Overall, adherence to the SAP guidelines was 99.4%, and compliance was highest for antibiotic selection (100%), dosing (100%), and postoperative duration (100%). Preoperative timing compliance was 97%, while 6% received unjustified prophylaxis. Elective surgeries (67%) predominated, with ceftriaxone (31%) and cefuroxime (31%) being the most prescribed antibiotics. Moreover, a significant gender disparity was observed, mostly (76%) in male patients.

Conclusion: Tear-perfect compliance with the SAP guidelines is achievable in resource-limited settings, demonstrating that strict adherence to the ASHP guidelines minimizes unnecessary antibiotic use while maintaining SSI prevention efficacy. The 6% unjustified prophylaxis rate highlights an opportunity for stewardship refinement. These findings provide a replicable model for optimizing SAP in global surgical practice.

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Introduction

Surgical interventions are now essential in modern healthcare as they help address many medical conditions, from elective surgery to emergency intervention. Demand for surgical services is growing worldwide due to an aging population and a rising prevalence of chronic diseases. However, challenges exist in providing surgical care due to resource limitations, unequal access to care, and disparities in surgical outcomes among different regions (1,2).

Prevention of surgical site infections (SSIs) is critical in enhancing the postoperative outcomes of patients. SSIs are serious complications that prolong hospital stays, increase healthcare costs, and can result in death. The World Health Organization underscores the fact that preventing SSIs can improve patient safety and reduce the healthcare burden. Proper implementation of best practices in surgical protocols, such as maintaining a

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sterile environment and wound care, will significantly reduce the risk of infection (3,4).

Antibiotic prophylaxis is a key strategy in reducing the incidence of SSIs. Administering antibiotics before surgical procedures can help prevent infections by eliminating potential pathogens that may enter the surgical site during the operation. Guidelines recommend specific antibiotic regimens based on the type of surgery and the patient's risk factors to optimize efficacy while minimizing adverse effects. The appropriate use of prophylactic antibiotics not only improves surgical outcomes but also contributes to the broader effort of combating antibiotic resistance by ensuring that antibiotics are used judiciously (5,6).

Effective antibiotic prophylaxis is crucial in preventing SSIs, which account for a significant proportion of nosocomial infections globally. Key principles include administering antibiotics within 30–60 minutes before incision to ensure optimal tissue concentrations, selecting agents based on likely pathogens and local resistance patterns (e.g., cefazolin for clean surgeries), weight-based dosing to achieve therapeutic levels, and limiting duration to a single dose or 24 hours post-surgery to reduce toxicity and resistance risks (7). However, global practices show considerable variation and gaps. For instance, studies highlight suboptimal adherence to guidelines, with inappropriate timing and prolonged use being common issues, leading to increased SSIs, antibiotic resistance, and healthcare costs (8). In South Africa, pharmacist-driven interventions improved compliance with prophylactic measures by 24.7%, reducing SSI rates by 19.7% (9). Similarly, a U.S. survey revealed inconsistent practices even in academic centers, emphasizing the need for standardized protocols. Addressing these disparities through education, stewardship programs, and adherence monitoring can enhance clinical outcomes and mitigate economic burdens (10).

Methods

Study setting

The study was conducted at Medax Hospitals, RT Nagar, a NABH-accredited healthcare facility in Bengaluru, Karnataka, India, recognized for its commitment to delivering high-quality medical care. The hospital's General Surgery and Minimal Access Surgery department is equipped with advanced technology and skilled surgeons, ensuring optimal surgical outcomes with reduced recovery times. This study focused on the hospital's surgical protocols and antimicrobial prophylaxis practices, which are central to its comprehensive approach to patient care. The facility's adherence to evidence-based practices and its emphasis on minimizing postoperative complications provided a robust foundation for evaluating the effectiveness of antibiotic prophylaxis and pain management strategies across diverse surgical modalities. The study was conducted from June 25 to August 15, 2024, and focused on a specific intervention. It was designed as a prospective study.

Study population, eligibility criteria, and patient selection

The Medax Hospitals surgical ward had a steady flow of patients with medical conditions requiring surgical treatment. The study population was carefully selected to ensure a representative patient demographic and relevance. Patients were closely monitored, with detailed records of their procedures, recovery, and complications maintained. This rigorous data collection was critical to the study's success, providing valuable insights into the effectiveness and outcomes of surgical treatments. The participation of patients in the ward played a crucial role in advancing medical knowledge and improving surgical practices.

Patients aged 18 years and above who underwent various surgical procedures, including multidisciplinary surgeries, received antibiotic prophylaxis as part of their preoperative and postoperative care, and who were willing to participate in the study, were included.

Patients who were unable to consent, undergoing surgeries with different preoperative protocols, or procedures without a significant surgical component, were excluded. Moreover, any patient with incomplete medical records or charts was also excluded.

The study used a systematic random sampling technique to select 95 patient profile cases from Medax Hospitals' records. The first patient chart was selected using a simple random sampling technique. The remaining cases were chosen considering every third chart selected until the desired sample size of 95 cases was reached.

Evaluation of surgical antimicrobial prophylaxis (SAP)

The study adhered to a structured protocol designed to evaluate compliance with the American Society of Health-System Pharmacists (ASHP) guidelines for surgical antimicrobial prophylaxis (SAP) practices. The assessment framework incorporated two key parameters:

-Indication and choice of antimicrobial agent

For indication, SAP administration was classified as appropriate if prophylaxis was either correctly administered when clinically warranted or omitted when

unnecessary, whereas it was deemed inappropriate if prophylaxis was erroneously withheld despite indication or administered without justification. The choice of antimicrobial agent was evaluated based on its spectrum of activity, with adequate coverage defined as alignment with anticipated surgical site pathogens, while narrow or broad coverage indicated insufficient or excessively wide-spectrum antimicrobial use, respectively. This systematic approach ensured a rigorous assessment of adherence to evidence-based SAP guidelines, facilitating the identification of potential areas for optimization in clinical practice.

-Timing, duration, dose, and administration of preoperative antimicrobial

The study evaluated the timing of preoperative antimicrobial dose administration relative to the surgical incision, a critical determinant of prophylactic efficacy. Adherence to the recommended window was classified as appropriate if the antimicrobial was administered 30–60 minutes before incision, ensuring optimal tissue concentrations at the time of potential bacterial exposure. Doses given more than 60 minutes prior were categorized as early, potentially resulting in subtherapeutic levels during surgery. In comparison, administration within 0–29 minutes before incision was classified as late, increasing the risk of insufficient drug distribution at the surgical site. This stratification aligns with established pharmacokinetic and pharmacodynamic principles, ensuring a systematic assessment of compliance with evidence-based timing guidelines for SAP. The agent was administered intravenously (appropriate) or by another route (inappropriate).

The study assessed the duration of SAP to determine adherence to evidence-based guidelines. Prophylaxis was classified as appropriate if discontinued within 24 hours after surgery, aligning with recommendations to minimize unnecessary antimicrobial exposure while maintaining efficacy. Conversely, SAP continuation beyond 24 hours postoperatively was deemed inappropriate, as prolonged administration does not enhance infection prevention and may contribute to antimicrobial resistance and adverse effects. This evaluation criterion reinforces the principle of optimizing antimicrobial stewardship by ensuring SAP is used judiciously, balancing clinical benefit against the risks of excessive antibiotic use. The assessment was consistent with established guidelines advocating for the shortest effective prophylactic duration.

Data Collection and Evaluation

Data on SAP practices were collected using a standardized data abstraction format based on the ASHP guidelines and other validated tools. Cases where SAP was not indicated were excluded from the detailed evaluation of other parameters. Compliance was determined based on whether all criteria were met for every case. Non-compliance was identified if any parameter deviated from the guidelines. All data analyses were performed using Jamovi (Version 2.3.28), an open-source statistical platform built on the R framework.

Results

Demographic and clinical characteristics of patients

A total of 94 individuals were finally analyzed, 76% of them (72 patients) were male, while 24% (22 patients) were female. As shown in Table 1, the most frequent age group was 25–34 years, constituting 35% of the patients. In this study, 39% of the patients had at least one comorbidity, while 61% had no comorbid conditions. Hypertension is the most common comorbidity, affecting 50% of those with comorbidities, followed by diabetes mellitus at 35% and hypothyroidism at 15%.

-Type of Surgery and Procedure

The types of surgeries performed were predominantly elective (67%). The variety of surgical procedures included thyroidectomy (1%), appendectomy (10%), cholecystectomy (8%), hernia repair (9%), benign prostatic hyperplasia (BPH) (4%), orthopedic surgeries (13%), skin and deep tissue surgeries (14%), and miscellaneous procedures (41%).

-Wound Classification

Wound classification is a critical aspect of evaluating postoperative outcomes. In this study, 51% of the patients had clean wounds, indicating a lower risk of infection. Clean-contaminated wounds were present in 36% of the patients, suggesting a moderate level of infection risk that is often associated with certain types of surgical procedures. Contaminated and dirty wounds were less common, occurring in 8% and 5% of the patients, respectively.

The Chi-Square test showed different frequencies in the type of surgery between males and females ($\chi^2 = 43.6$, $df = 7$, $p < 0.001$). The results indicated that 100% of the surgeries performed on women were miscellaneous, while miscellaneous (22%), skin and deep tissue (13%), and orthopedic (12%) surgeries were the three most common surgeries in males.

The Chi-Square test revealed a significant association between age group and surgical type ($\chi^2 = 247$, $df = 42$, p

< 0.001). In all age groups, miscellaneous surgeries were the most common type except for group 18-24 years, in which appendectomy had the same frequency. The frequency of miscellaneous surgeries in patients aged 25-34 years, 65-74 years, and 75-85 years old was 47%, 55% and 46%, respectively.

Table 1. Demographic and clinical Characteristics of the study patients

Variables		Frequency	Percentage
Sex	**Male**	72	76%
	Female	23	24%
Age group (years)	**18-24**	11	12%
	25-34	34	35%
	35-44	12	13%
	45-54	6	6%
	55-64	10	11%
	65-74	9	9%
	75-85	13	14%
Type of surgery	**Elective**	64	67%
	Emergency	31	33%
Type of procedure	**Thyroidectomy**	1	1%
	Appendectomy	9	10%
	Cholecystectomy	8	8%
	Hernia repair surgeries	9	9%
	Benign prostate hyperplasia surgeries	4	4%
	Orthopaedic surgeries	12	13%
	Skin and deep tissue surgeries	13	14%
	Miscellaneous†	39	41%
Wound classification	**Clean**	49	51%
	Clean- contaminated	34	36%
	Contaminated	7	8%
	Dirty	5	5%
Comorbid condition	**Yes**	37	39%
	No	58	61%
Type of comorbidity	**Hypertension**	17	50%
	Diabetes mellitus	12	35%
	Hypothyroidism	5	15%

†Miscellaneous: Procedures include exploratory laparotomy, endovenous ablation with anal dilation and laser hemorrhoidoplasty, high ligation hemorrhoidal artery, staple and laser circumcision, dilation and curettage (various types), hysteroscopy, percutaneous nephrolithotomy, double J stent removal, left atrioventricular fistula surgery, percutaneous endoscopic gastrostomy feeding tube insertion, total and laparoscopic hysterectomy, Jaboulay's procedure, chest liposuction, and varicose vein treatments.

Appropriateness of antimicrobial prophylaxis in terms of indication

The appropriateness of SAP in terms of indication is summarized in Table 2. A substantial majority of patients, 81 individuals (85%), received antimicrobial prophylaxis when it was indicated. In nine cases (9%), antimicrobial prophylaxis was neither indicated nor administered. There were no instances (0%) where antimicrobial prophylaxis was indicated but not administered. In five cases (6%), antimicrobial prophylaxis was administered despite not being indicated.

Table 2. Surgical antimicrobial prophylaxis appropriateness in terms of indication

Variables	Frequency	Percentage
Antimicrobial prophylaxis was indicated and administered	81	85.3%
Antimicrobial prophylaxis was not indicated and not administered	9	9.5%
Antimicrobial prophylaxis was indicated, but not administered	0	-
Antimicrobial prophylaxis was not indicated, but was administered	5	5.2%

Antimicrobials were prescribed as preoperative and postoperative prophylactic agents

Table 3 provides a summary of the antimicrobial agents used for prophylaxis at Medax Hospital during the study period, both preoperatively (86 cases) and postoperatively (64 cases). Ceftriaxone was the most frequently used antibiotic preoperatively (in 31% of the cases) and postoperatively (in 28% of the cases). Cefuroxime Sodium was another widely used antimicrobial, administered in 31% of preoperative cases. It also constituted the second most used agent postoperatively (in 27% of the cases). Ceftriaxone-Sulbactam, used in 17% and 23% of preoperative cases, respectively and was the third widely used agent.

Table 3. Antimicrobials prescribed as preoperative (n=86) and postoperative (n=64) prophylactic agents

Antimicrobial Agent	Preoperative N(%)	Postoperative N(%)
Ceftriaxone	25(31)	18(28)
Ceftriaxone and Sulbactam	14(17)	15(23)
Ceftriaxone-tazobactam	2(2)	2(3)
Cefuroxime Sodium	25(31)	17(27)
Cefotaxime	10(12)	6(9)
Cefoperazone sodium	1(1)	1(2)
Piperacillin-tazobactam	5(4)	1(2)
Amoxicillin-clavulanate	2(1)	2(3)
Meropenem	2(1)	2(3)

N: Number

Compliance with the surgical antibiotic prophylaxis guidelines

Table 4 presents the results of the evaluation of SAP utilization in study patients. Regarding the indication for SAP, 95% of the cases were deemed appropriate. In terms of the choice of antibiotics, all 95 cases adhered to the appropriate selection criteria, with no instances of narrow-spectrum or broad/unnecessary combinations observed. Similarly, when examining the dosing of antibiotics, the results showed that 100% of the cases had accurate dosing, with no reports of sub-dosing or overdosing. In terms of the duration of preoperative prophylaxis, 97% of the cases fell within the recommended 60-minute window before the surgical procedure. The duration of postoperative prophylaxis also showed that 100% of the cases received the appropriate duration of less than 24 hours.

Table 4. Evaluation of surgical antimicrobial prophylaxis in study patients

Variables		Frequency, N (%)
Indication		
	Appropriate	90 (95%)
	Inappropriate	5 (5%)
Choice		
	Adequate	95 (100%)
	Narrow	0 (0%)
	Broad/unnecessary combination	0 (0%)
Dose		
	Accurate	95 (100%)
	Sub-dose	0 (0%)
	Over-dose	0 (0%)
Route		
	Appropriate	95 (100%)
	Inappropriate	0 (0%)
Duration of preoperative prophylaxis		
	Within 60 minutes	92 (97%)
	Outside 60 minutes	3 (3.1%)
Duration of postoperative prophylaxis		
	< 24 hours	95 (100%)
	≥ 24 hours	0 (0%)

N: Number

The compliance of the study SAP with the ASHP guidelines is shown in Figure 1.

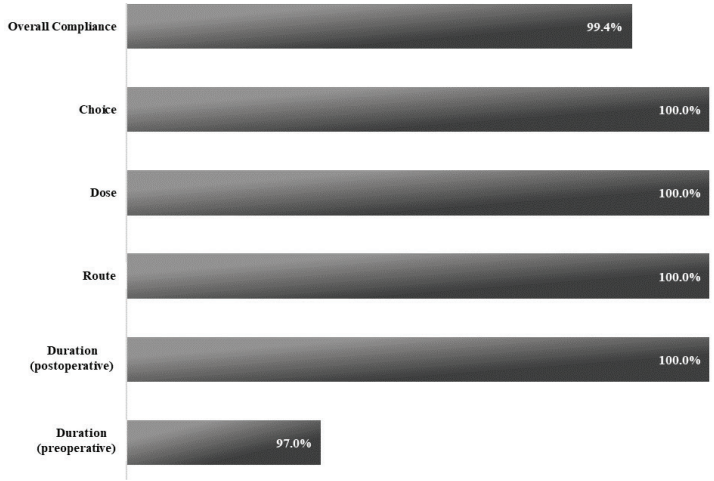

Figure 1. Compliance of Surgical antimicrobial prophylaxis use with the ASHP surgical site infection prevention guideline

Discussion

The results of this study offer some insights into the demographic and surgical characteristics and antimicrobial prophylaxis practices at Medax Hospital. The types of surgeries performed, with a predominance of elective procedures (67%), suggest that most patients underwent planned surgeries, which typically allow for better preoperative planning and potentially better outcomes compared to emergency surgeries.

The wound classification data, with over half of the patients having clean wounds, further support the likelihood of favorable postoperative outcomes, as clean wounds are associated with lower infection risks. The presence of comorbid conditions in 39% of the patients, particularly hypertension and diabetes, underscores the importance of managing chronic diseases in the perioperative period to optimize surgical outcomes.

The study also highlights a high level of adherence to antimicrobial prophylaxis guidelines, with 85% of the patients receiving prophylaxis when indicated and no instances of prophylaxis being omitted when needed. However, the 6% of cases in which prophylaxis was administered without indication suggest a need for continuous review of protocols to minimize unnecessary antibiotic use, which is critical in combating antimicrobial resistance.

The detailed analysis of preoperative and postoperative antimicrobial use reveals a strategic approach to infection prevention, with a preference for broad-spectrum antibiotics like ceftriaxone and cefuroxime sodium. The consistent use of these agents underscores their effectiveness in reducing postoperative infections, while the selective use of combination therapies highlights an evidence-based approach to addressing specific surgical risks.

The evaluation of compliance with the SAP guidelines demonstrates an impressive adherence rate of 99.4%, reflecting the hospital's commitment to maintaining high standards of care and patient safety. Antibiotic prophylaxis is a crucial aspect of surgical care, aimed at reducing the risk of SSIs and other postoperative complications. However, the practices and guidelines vary across different surgical specialties and procedures. Here, we discuss the current state of antibiotic prophylaxis practices in various surgical modalities (11).

In orthopedic surgery, particularly joint arthroplasty procedures, antibiotic prophylaxis is commonly used. A survey of orthopedic surgeons in the United States found that the majority (74.5%) routinely recommend prophylactic antibiotics for all patients with total joint arthroplasties undergoing dental procedures. The majority of the surgeons (81.9%) were aware of the current guidelines from the American Academy of Orthopaedic Surgeons and American Dental Association, but this awareness did not significantly affect their antibiotic prophylaxis practices (12).

In trauma surgery, antibiotic prophylaxis for tube thoracostomy placement remains controversial. A systematic review and meta-analysis found that patients who received antibiotic prophylaxis were significantly less likely to develop empyema, with greater benefit in patients with penetrating injuries. The Eastern Association for the Surgery of Trauma recommends antibiotic prophylaxis for tube thoracostomy placement in trauma patients. Medication therapy management is a collaborative approach to optimize medication use and improve patient outcomes (13).

A significant gap exists in adherence to the established

guidelines for SAP. A study indicated that only 58.3% of patients adhered to recommended practices, with notable deficiencies in the timing, choice, and duration of antibiotics used. This finding highlights the need for further research into the factors influencing compliance and the development of strategies to improve guideline adherence (14).

In contrast to the current study, the pattern of prophylactic antibiotic use before cardiac surgery did not comply with the ASHP guideline in terms of dosing, re-dosing, and duration of antimicrobial prophylaxis in a cardiac study in Iran. Another study in gynecological surgery patients, showed that the degree of SAP adherence to the guideline was 99.72% for the type of antibiotic selected, 98.8% the initiation time, 1.6% for the prescribed dose, 29.48% in redosing of antibiotics during the procedure, if necessary, and 0% in the duration of antibiotic prophylaxis 0% (15). Inappropriate SAP, in addition to short-term and long-term costs, results in the development of multidrug-resistant microorganisms.

The limitations of this study include, small sample size, not registering and reporting the culture results, and reporting the doses of antibiotics.

Conclusion

The study results show a high level of adherence to the ASHP guidelines, with an overall compliance rate of 99.4%. The findings indicate that the hospital follows evidence-based protocols in the indication, choice of antimicrobial agent, timing, dosing, route of administration, and duration of prophylaxis, minimizing unnecessary antibiotic use while ensuring optimal infection prevention. However, the 6% incidence of unjustified antibiotic administration highlights an area for improvement, emphasizing the need for continuous education and antimicrobial stewardship programs to further refine prescribing practices. The predominance of male patients (76%) and elective surgeries (67%), along with the effective management of comorbid conditions, underscores the hospital's structured approach to perioperative care. The preferential use of broad-spectrum antibiotics (ceftriaxone, cefuroxime sodium) aligns with global recommendations, although periodic reviews of local resistance patterns could further optimize agent selection. These results reinforce the importance of standardized SAP protocols in reducing SSIs and combating antimicrobial resistance. Future research should explore long-term outcomes of SAP adherence, cost-effectiveness of prophylactic regimens, and interventions to eliminate unnecessary antibiotic use in low-risk cases.

Conflict of Interests

The authors have nothing to declare.

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