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Original Article

Assessment of Antibiotic Prophylaxis in Surgical Patients at a Referral Teaching Hospital in Western Iran

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Abstract

Background: Antibiotic prophylaxis is often used by surgeons to prevent surgical site infection (SSI) following operations. Despite the availability of several national guidelines for proper antibiotic prophylaxis, adherence to guideline recommendations, especially in developing countries, is still sub-optimal. This study aimed to assess adherence to the American Society of Health-System Pharmacists (ASHP) guidelines for prophylactic antibiotic use among surgeons in a referral hospital in western Iran.

Methods: This prospective cross-sectional study was conducted in surgery wards of a tertiary hospital affiliated with Hamadan University of Medical Sciences, Hamadan, Iran, for six consecutive months from February 1 to July 31, 2019. The records of 264 patients who were randomly chosen from patients admitted to surgery wards were reviewed. The appropriateness of parameters of surgical antibiotic prophylaxis, including indication, antibiotic choice, dose, timing of the first dose, and duration of prophylaxis, was assessed against ASHP guidelines.

Results: A total of 248 patients (93.94%) received antibiotic prophylaxis. Only in 32.2% of the procedures, full adherence to all parameters of the AHSP guidelines was achieved. In a significant percentage of procedures, prophylactic antibiotics were administered inappropriately for more than 24 hours (59.21%). Regarding the antibiotic selection (92.1%), dose (88.6%), and timing of administration (89.9%), the rate of adherence to guidelines recommendations was relatively satisfactory in our hospital.

Conclusion: Our survey demonstrated that the adherence of surgeons to antibiotic prophylaxis guidelines was inadequate in our hospital, and there is still considerable room for improvement, especially in the process of discontinuation of antimicrobial prophylaxis.

Keywords: Antimicrobial stewardship, Guideline adherence, Surgical procedure, Antibiotic prophylaxis

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Introduction

Surgical site infection (SSI) is a prevalent and grave complication following surgery, with a reported incidence of approximately 38%, which is related to high morbidity, mortality, and healthcare costs (1). The risk of SSI depends on many patient-related factors, including age, existing infections, nutritional status, obesity, and comorbidities, as well as surgical factors, such as duration of the procedure and the type of operation (clean, clean-contaminated, contaminated, or dirty-infected) (2). Therefore, antibiotic prophylaxis is often used by surgeons to prevent SSIs following operations. The goal of antimicrobial prophylaxis during the operative procedure is to reduce the burden of microorganisms at the surgical site and, consequently, prevention of SSIs (3). Prophylactic antibiotics are selected based on the spectrum of activity, susceptibility of pathogens, duration of action, cost, and other parameters (4). Although the effectiveness of antibiotic prophylaxis for the prevention and reduction of SSI is well established (5), inappropriate prescription of antimicrobial prophylaxis not only increases the risk of adverse effects and prevalence of antimicrobial resistance on surgical wards but also increases drug costs and waste of healthcare resources (6). In order to improve the quality of antimicrobial prophylaxis during the operative procedure, several national guidelines have been developed to provide practitioners with a standardized approach to the rational, safe, and effective use of antimicrobial agents for the prevention of SSIs. According to guideline recommendations, antibiotic prophylaxis is indicated in surgical procedures associated with a high risk of infection (clean-contaminated or contaminated operations and in

some clean surgical wounds, such as vascular prostheses and orthopedic implants) (4,7). Despite the availability of these guidelines, especially in developing countries, the practice of antibiotic prophylaxis is still far from optimal, and a large number of patients are exposed to unnecessary drug use. In this respect, a survey of European hospitals reported that half of the surgical patients in 2006 had received antibiotic prophylaxis for more than 24 hours after the end of surgery without reason (8). In a recent study involving 14 hospitals in Germany, the rate of adherence to local perioperative antibiotic prophylaxis guidelines ranged widely from 5 to 85% (9). The difficulty encountered by physicians to update their knowledge, their dependence on habits originating from clinical practice rather than from evidence, the lack of policies, and failure in the implementation of institutional guidelines are some factors that cause non-adherence to prophylaxis protocols (10). Some studies have investigated interventions of varying intensity to increase the use of clinical practice guidelines (11). Results of these studies demonstrated that the introduction of an educational program combined with audit and feedback, computer-assisted clinical decision support, educational materials, and continuing education meetings are some interventions that can improve physician adherence to guideline recommendations (12,13). Therefore, monitoring surgical antibiotic prophylaxis is crucial in ensuring the appropriate use of antimicrobial agents in this setting. In developing countries such as Iran, a small number of papers have been published on this topic. However, the existing studies on the assessment of surgeons' adherence to antimicrobial prophylaxis guidelines indicate poor clinical practice (14,15). Considering the aforementioned studies, this study aimed to assess the adherence to the American Society of Health-System Pharmacists (ASHP) guidelines (4) for prophylactic antibiotic use among surgeons in the large teaching hospital in western Iran, affiliated with Hamadan University of Medical Sciences, Hamadan, Iran, over a six-month period. This study was done to identify gaps and design appropriate interventions to improve the future utilization of surgical antimicrobial prophylaxis.

Materials and Methods

This prospective cross-sectional study was conducted in the surgical wards of "Besat" teaching hospital, which is a tertiary referral hospital in western Iran, for six consecutive months from February 1 to July 31, 2019.

A sample size of 310 patients was calculated, considering a 50% likelihood of appropriate use of antibiotic prophylaxis, $\alpha = 5\%$, a power of 90%, and a 20% drop-out rate.

The statistical software randomly selected the study population from patients who underwent surgical procedures during the study period. Patients who aged 18 years or older and underwent clean, clean-contaminated, and contaminated procedures were included in the study. The American College of Surgeons wound classification schema (4) was used to categorize operative procedures into clean, clean-contaminated, and contaminated. The procedures classified as dirty-infected wounds were excluded from the study due to the use of antimicrobial agents for dirty procedures, and established infections are classified as treatment of presumed infection, not prophylaxis. Exclusion criteria were as follows: pediatrics (< 18 years old), dirty procedures, therapeutic and other non-surgical prophylaxis uses, and presence of infection and/or antibiotics before surgery. Additionally, patients whose medical records were incomplete were excluded from the study. We included patients from general, orthopedic, oral and maxillofacial, neurosurgery, ENT (ear, nose, and throat), gynecology, and plastic surgery wards. It should be mentioned that at the time of the present study, there was no standard protocol in the wards or in the operating room of the hospital that guided the use of antimicrobial agents for certain procedures, based on the interpretation of the guidelines.

The data collection form was prepared based on previously published studies (16,17). The data collection form was divided into four sections: (a) patients' demographic and medical data, (b) surgical data (surgical ward in which the patient was admitted, types of surgery, time of incision, and wound class), (c) data on the use of surgical antibiotic prophylaxis (antibiotic name, route of administration, dose, frequency, preoperative administration time relative to skin incision and duration of prophylactic administration), and (d) data on the use of appropriate surgical antibiotic prophylaxis (indication, selection, dose, duration, and timing). The medical records of each patient were reviewed by a clinical pharmacist during the postoperative period while patients were still in the hospital, and based on this, all relevant data were collected from the patient's medical records. If any item of data in the patient chart was unclear, the clinical pharmacist interviewed the nurses and related surgeons.

The appropriateness of surgical antibiotic prophylaxis use was assessed against the ASHP guidelines, which are the complete guidelines available for the rational use of antimicrobials as preoperative prophylaxis. The appropriateness of antibiotic prophylaxis was evaluated in terms of the necessity for surgical antibiotic prophylaxis use (indication), choice of antibiotic (selection), preoperative timing (timing), dose, and total duration of prophylaxis (duration).

If an antibiotic was given while it was not indicated or vice versa, and if an antibiotic was not given while it was indicated, the other parameters were also considered inappropriate. Therefore, the other parameters of antibiotic choice, dose, dosing interval, and timing were not evaluated in these cases. If the surgical procedure justifies the use of prophylactic antibiotics, and it was given, the following parameters would be evaluated: (a) appropriateness of antibiotic selection, (b) appropriateness of dose of the antibiotic, (c) appropriateness of timing for antibiotic administration, and (d) appropriateness of

duration of antibiotic prophylaxis. Antibiotic prophylaxis was considered inappropriate when at least one of the mentioned aspects of antimicrobial prophylaxis did not conform to the adopted guideline. If more than one drug was prescribed for a single operation, all parameters for each drug were evaluated separately. Any divergence from the guidelines in the prescription of one of the drugs led to a final assessment of the prophylactic course as discordant with the guidelines. Complete compliance (100%) was achieved when all the attributes of quality indicators met the criteria of the ASHP surgical antibiotic prophylaxis guidelines.

The obtained data were entered into the SPSS version 16.0 (SPSS Inc., Chicago, IL, USA), double-checked by an investigator, and analyzed. Categorical and numerical variables were expressed as frequencies (percentages) and mean ± standard deviations (SD), respectively.

Results

Medical records of 310 surgical patients who met inclusion/exclusion criteria were followed and evaluated over a 6-month period from July 1, 2019 to December 31, 2019. Forty-six patients were excluded due to incomplete medical data. Finally, the information of 264 patients was recorded and analyzed at the end of the study.

The mean ± SD age of the study participants was 41.30 ± 16.49 years, and the range of ages was between 18 and 85 years. The population of the study consisted of 168 men (63.6%) and 96 women (35.4%). Of these patients, 211 (79.92%) underwent elective surgery, and 53 (20.08%) underwent emergency surgery. The most common surgeries were conducted in orthopedic (34.8%), general (23.1%), and neurosurgery wards. The most common procedure was exploration (38.56%), followed by laminectomy (12.1%) and open reduction internal fixation (ORIF) (12.1%), while craniotomy, thoracotomy, and knee joint replacement were the least commonly performed procedures. The majority of the procedures were clean-contaminated (59.5%), followed by contaminated (20.8%). Additionally, 9.1% of procedures (24 cases) were clean, in which, based on guideline recommendations, antibiotic prophylaxis is not indicated, while 10.6% of cases were certain clean procedures (inserted prosthetic devices), and despite the low risk of infection, these procedures were candidates for antibiotic prophylaxis due to severe consequences of infection. The duration of the majority of surgical operations (90.15%) did not exceed 3 hours and about 76.51% of the procedures were performed in the morning. The demographic characteristics of study participants and their surgical information are listed in Table 1.

Of 264 patients included in the analysis, 248 patients (93.94%) received antibiotic prophylaxis. The antimicrobials used for prophylaxis are summarized in Table 2. The most frequently prescribed antibiotic was cefazoline (79.16%, used in 209 out of 248 patients to whom prophylaxis was given), followed by metronidazole (used in 15 procedures), and ceftriaxone (used in 14 procedures). The frequency of the types of antimicrobial agents used for prophylaxis is shown in Table 2.

Antibiotic prophylaxis was indicated in 240 patients (90.90%), but in our survey, it was administered to 93.94% of patients (248 patients). Only in 4 out of 24 procedures (16.7%) in which antimicrobial prophylaxis was not indicated (clean non-prosthetic uncomplicated surgeries), prophylaxis was not administrated. Therefore, in 83.3% of these procedures, antimicrobial prophylaxis was administrated improperly. On the other hand, of 240

Table 1. Demographic Characteristics of Patients and Surgical Information

	Variable	N = 264	Percent
Gender	Male	168	63.6
	Female	96	36.4
Age (y)	Mean ± SD	41.30 ± 16.49	
	Range	18-85	
Type of surgery	Elective	211	79.92
	Emergent	53	20.08
Surgical ward	Orthopedic	92	34.8
	General surgery	61	23.1
	Neurosurgery	52	19.7
	ENT	17	6.4
	Gynecology	16	6.1
	Oral and maxillofacial	14	5.3
	Trauma	12	4.5
Procedure	Surgical exploration	102	38.56
	Laminectomy	62	23.5
	ORIF	32	12.1
	Cholecystectomy	28	10.6
	Rhinoplasty	17	6.4
	Appendectomy	7	2.7
	Fixation	6	2.3
	Septorhinoplasty	4	1.5
	Craniotomy	2	0.8
	Thoracotomy	2	0.8
	Knee joint replacement	2	0.8
Type of surgical wound	Clean-contaminated	157	59.5
	Contaminated	55	20.8
	Clean non-prosthetic	24	9.1
	Clean prosthetic	28	10.6

ENT: ear, nose, and throat, ORIF: open reduction and internal fixation.

Table 2. Types of Antimicrobial Agents Used for Surgical Prophylaxis

Name of antibiotic(s)	N	Percent
Cefazolin	209	79.16
Cefazolin + Metronidazole	15	5.86
Gentamycin	2	0.08
Ceftriaxone	14	5.3
Cefazolin + Gentamycin	6	2.3

Note: Prophylaxis was used in 248 procedures.

patients for whom antibiotic prophylaxis was indicated according to the ASHP guidelines, 228 cases (95%) received antibiotic prophylaxis. In other words, only 5% of these cases did not receive antibiotic prophylaxis. These results demonstrated that using antimicrobial prophylaxis without indication in clean procedures was common practice among surgeons in our hospital.

Four different parameters of the appropriateness of prophylaxis, including the antimicrobial agent, antimicrobial dose, the timing of administration of the first dose, and the duration of prophylaxis, were assessed in 228 patients to whom, according to the guideline recommendations, antibiotic prophylaxis was appropriately administered. Regarding the antimicrobial agent, 92.1% of the patients (210 out of 228 patients) received an antimicrobial agent that was recommended by the guideline. With respect to the adequacy of the initial dose of antibiotics, adequate doses were given to 88.6% of the patients (202 out of 228 patients). In evaluating the timing of administration of the first dose of prophylaxis, it was observed that about 89.9% of the administrations (205 out of 228 patients) were performed in the appropriate preoperative period (within 0 to 60 minutes before incision as recommended by the guidelines). Finally, regarding the duration of antimicrobial prophylaxis, 40.8% of the patients (93 out of 228 patients) received antimicrobial prophylaxis according to the guideline recommendations. The mean duration of antibiotic prophylaxis was 3.6 ± 2.4 days (ranging from one or two doses of antimicrobials during the day of operation up to 10 days), and in a significant percentage of procedures, prophylactic antibiotics were administered for greater than 24 hours (59.21%).

Therefore, the most common reason for inappropriate prophylactic antibiotic use in our study was inappropriate duration.

Overall, a total of 264 patients were evaluated in this study. Only 32.2% of the procedures (85 procedures) achieved full adherence to all parameters of the AHSP guidelines, which include an indication, choice of antibiotic, dose, duration, and timing of the first dose. In 67.8% of procedures (179 procedures), non-adherence to at least one of the aspects of the ASHP surgical prophylaxis guidelines was observed. Table 3 shows the frequency of appropriateness of antibiotic prophylaxis according to the AHSP guideline recommendations.

On the wards participating in our study, the adherence to the guideline for antibiotic prophylaxis ranged from 8.33 to 88.23%. Therefore, the overall adherence to the guidelines recommendations was noted in the participating surgical wards in our study. While adherence rates of ≥ 80% were achieved in the ENT ward, some wards, such as trauma, showed poor adherence rates (≤ 10%). Therefore, the degree of surgeons' familiarity with guideline recommendations varied widely in different wards of our hospital. The results related to the frequency of appropriateness of antibiotic prophylaxis in the different surgical wards have been shown in Table 4.

Discussion

We found that total adherence to the prophylactic antibiotic guidelines in our hospital was relatively low, and in 67.8% of cases, the discrepancy in guideline recommendations at least in one of the parameters, including indication for use or non-use of antibiotics, antibiotic choice, initiation time, and duration of antibiotic prophylaxis was observed. The major discrepancy was found in antibiotic administration duration, and in a significant percentage of procedures,

Table 3. Frequency of Appropriateness of Antibiotic Prophylaxis According to the Clinical Guidelines

Variable		Frequency	Percent
Full compliance with ASHP guidelines (in 264 patients)		85	32.2
Non-compliance with at least one of the aspects of antimicrobial prophylaxis		179	67.8
Use of antibiotics in patients for whom antibiotic prophylaxis was indicated: (in 24 patients)	Not indicated and not administered	4	16.7
	Not indicated but administered	20	83.3
Use of antibiotics in patients for whom antibiotic prophylaxis was indicated (in 240 patients)	Administered	228	95
	Not administered	12	5
Total adherence in patients for whom antibiotic prophylaxis was indicated and administrated (in 228 patients)	Full adherence to ASHP guidelines	81	35.5
	Non-compliance with at least one of the aspects of antimicrobial prophylaxis	147	64.5
Choice of antibiotic	Appropriate	210	92.1
	Inappropriate	18	7.9
Dose of the antibiotic	Appropriate	202	88.6
	Inappropriate	26	11.4
Timing of administration	Appropriate	205	89.9
	Inappropriate	23	10.1
Duration of prophylaxis	Appropriate	93	40.8
	Inappropriate	135	59.2

Table 4. Adherence to the AHSP Guidelines in the Different Surgical Wards

Variable	Full adherence, No. (%)	Non-adherence*, No. (%)
Orthopedic	18 (19.56)	74 (80.43)
General surgery	8 (13.11)	53 (86.88)
Neurosurgery	32 (61.53)	20 (38.46)
ENT	15 (88.23)	2 (11.76)
Gynecology	3 (18.75)	13 (81.25)
Oral and maxillofacial	8 (57.14)	6 (42.85)
Trauma	1 (8.33)	11 (91.66)

Note. ENT: ear, nose, and throat.
* Non-adherence to at least one of the aspects of antimicrobial prophylaxis.

prophylactic antibiotics were administered for more than 24 hours, whereas appropriateness of initiation time, selection of antibiotic, and dose of antibiotics were relatively more satisfactory parameters.

Evaluation of surgeons' compliance with surgical antibiotic prophylaxis guidelines has been carried out in many institutions (18). A previous study conducted in teaching hospitals in Iran found that total compliance with prophylactic antibiotic guidelines in neurosurgical procedures was less than 1%, which was considerably lower compared to our findings (19). Moreover, another prospective study in Iran revealed that although overall compliance with guidelines in the surgical wards of private hospitals was significantly higher compared to teaching hospitals, approximately 90% of patients received inappropriate surgical prophylaxis (20). In another study in Iran, Vessal et al also reported poor compliance with international guidelines in a university teaching hospital, and only one surgical procedure adhered to all antibiotic prophylaxis guideline parameters (16). Similarly, one retrospective study in Korea showed that the rate of adherence to surgical practice guidelines in patients who underwent arthroplasty, colon surgery, or hysterectomy is very low and only 0.8% of the procedures achieved full adherence to all parameters of the local hospital guidelines (17). In an Italian survey conducted in 2013, surgical antibiotic prophylaxis was administered according to international and national recommendations for the prevention of SSIs in less than 20% of patients (21). In a Brazilian hospital, compliance with the Hospital Infection Control Committee guideline for antibiotic prophylaxis was investigated, and the compliance index was reported to be 5.8%, 3.1%, and 3% for orthopedic, neurologic, and cardiac surgeries, respectively (22). Therefore, although total compliance to the perioperative antibiotic prophylaxis guideline in the percent study was inadequate, it is relatively higher compared to the mentioned studies. However, higher rates of adherence to antimicrobial prophylaxis guidelines were reported in other studies compared to our study. In a large prospective multicenter study conducted in France, 41.1% of all the patients received surgical antibiotic prophylaxis in complete compliance with clinical practice guidelines (23). Two cross-sectional studies carried out in a tertiary referral teaching hospital in Italy and a tertiary care private hospital in India found that total compliance with surgical antibiotic prophylaxis guidelines was observed in 44.8% (24) and 52% (25) of cases, respectively. Additionally, a study conducted in 7 hospitals in Germany revealed that guidelines for antibiotic prophylaxis were followed in 70.7% of the cases who underwent surgery (9), which was considerably higher compared to our results (32.2%). Therefore, wide variation in compliance with guidelines for antibiotic prophylaxis has been reported in previous studies; however, in the majority of the studies, the overall compliance is relatively low. The inclusion of different populations in studies, conduction of studies in different countries, comparison of studies on a single type of surgical procedure or between very different surgical specialties, use of different methods in the studies, adoption of different guidelines for antibiotic prophylaxis, partial analysis of outcomes of interest in some studies, and possibility of incomplete records in patients' charts are possible factors that may explain these wide variations in the results of available studies.

The most remarkable discrepancies in our study were the inappropriate use of antibiotic prophylaxis in clean procedures and prolonged surgical prophylaxis administration beyond ASHP recommendations.

Based on ASHP guidelines, antibiotics are not indicated for clean procedures except those involving the prosthetic placement due to the possibility of severe complications if postoperative infections involve the prosthesis (4). Despite these recommendations, in our study, antibiotic prophylaxis was administered inappropriately to 83.3% of patients with clean non-prosthetic uncomplicated surgery (20 out of 24), and only four patients (16.7%) did not receive antibiotic prophylaxis. In 240 procedures, antibiotic prophylaxis was necessary (clean-contaminated or contaminated procedures). In 95% of these cases (228 out of 240), antibiotic prophylaxis was correctly administrated, and only in 5% of cases (12 out of 240), who had indications for antibiotic prophylaxis, it was not used. This suggests that although surgeons in our hospital were aware of the role of antibiotics in preventing SSIs, inappropriate use of antibiotic prophylaxis for surgical procedures in which prophylactic antimicrobials were not indicated was common in their routine clinical practice. A study by Rafati et al using the ASHP guideline, as a reference, found that prophylaxis was inappropriately administered to a significant percentage of patients who underwent clean operations (26). Consistent with our results, an observational study carried out by Tourmousoglou et al also revealed that antibiotic prophylaxis was inappropriately administered in 19% of patients with clean operations such as inguinal hernia repairs without a mesh, breast operation, and thyroidectomies (27). Overuse of antibiotics in clean procedures is associated with adverse consequences such as direct toxicity, change in the normal microbiota, and promotion of bacterial resistance (28).

As was seen, prolonged antibiotic use was the main point of noncompliance with guidelines in our study. In 59.21% of the patients for whom surgical antibiotic prophylaxis was indicated and administered (135 out of 228 patients), the antibiotic administration continued for more than 24 hours (the mean duration of antibiotic prophylaxis was 3.6 ± 2.4 days). Despite enough evidence related to the administration of antibiotic prophylaxis within 24 hours (4), it is still common practice for surgeons to continue antibiotic prophylaxis beyond 24 hours for most surgical procedures. Some studies demonstrated that there is a major misconception among surgeons that high-end or multiple antibiotics and prolonged therapy are more effective in preventing SSI when compared to a short course of narrow spectrum antibiotics (29,30). Therefore, additional efforts should be made to increase the awareness of surgeons about the dangers of the inappropriate use of antimicrobial agents.

With regard to the duration of antibiotic prophylaxis, adherence to guidelines in a previous study ranged between 5.8% and 91.4% (29) In a study performed by Vessal et al in Iran, antibiotic prophylaxis was continued in 83% of cases, while this was necessary in only 37% of cases (16). Similarly, in the study performed by Al-Momany et al in Jordan, the duration of antibiotic prophylaxis was longer than guideline recommendations in 58.9% of cardiac surgeries (31). Prolonging antibiotic prophylaxis beyond the recommended duration not only fails to improve SSI rates but could also lead to the emergence of multidrug-resistant pathogens, exposes patients to more adverse drug effects, and increases the overall costs on the health care system (32-34). Miliani et al showed that too-long surgical antibiotic prophylaxis duration did not decrease the risk of SSI (35). Additionally, previous studies comparing single-dose prophylaxis to multiple-dose prophylaxis reported that short-duration prophylaxis is equally effective as longer-duration administration in preventing SSIs (29,36).

Interestingly, although the present study reported low adherence to guideline recommendations regarding the indication and duration of antibiotic prophylaxis, the rates of adherence to the antibiotics selection (92.1%), dose of antibiotics (88.6%), and timing of administration of antimicrobial prophylaxis before incision (89.9%) were relatively higher than those reported in several previous studies (19,37,38).

The success of antimicrobial prophylaxis requires the delivery of the antimicrobial agent to the operative site before contamination occurs. Based on the ASHP guidelines, any time within 0–60 minutes before surgical incision is considered an appropriate time for antibiotic administration in all types of surgeries (4). Milston et al, in their study, found that the timing of antibiotic prophylaxis administration is an independent and modifiable risk factor for deep SSIs (39). In addition, results of a systematic review and meta-analysis demonstrated that the administration of antibiotic prophylaxis for more than 120 minutes before incision or after the incision is associated with a higher incidence of SSIs (40). Therefore, the efficacy of surgical antimicrobial prophylaxis is highly dependent on the timing of the drug administered. According to previous studies, significant variations were observed in the adherence to the timing of antibiotic prophylaxis administration (ranging from 22.3% to 100%) (18). A prospective multicenter study by Lallemand et al in 18 hospitals noted that 61.4% of the patients who did not receive prophylaxis at the optimal time were treated too late (23). A prospective Jordanian study on patients who underwent cardiac surgery revealed that 99.1% of these patients received prophylaxis within 60 minutes prior to skin incision as recommended by guidelines, but 97.0% of them received an unnecessary midnight dose of intravenous antibiotic the night prior to surgery (31). It seems that in our hospital, the adherence of surgeons to guideline recommendations on this parameter is relatively satisfactory.

The antimicrobial agent selected for surgical prophylaxis must be active against the most common pathogens at the surgical site. Accordingly, prophylaxis with cefazolin as a single agent was recommended by most guidelines for antibiotic prophylaxis in the majority of the surgical procedures (4). Similar to other parameters, significant variations in the appropriateness of antibiotic selection in the literature have been reported (ranging from 22% to 95%) (18). In the percent study, cefazolin was the most commonly used antibiotic for antibiotic prophylaxis. Our results showed that the choice of antibiotics used for prophylaxis was appropriate for the majority of the patients (89.1%). Therefore, among study parameters, the selection of antibiotics enjoyed higher compatibility with guidelines. Similarly, according to some published investigations, the selection of antibiotics was appropriate for surgical prophylaxis in the United States of America (in 95% of surgical procedures (41) and Brazil (in 75% of surgical procedures) (42). However, reports from some other studies revealed that antibiotics used for prophylaxis frequently were inappropriately chosen. In this respect, a study by Al-Azzam et al found that antimicrobial selections were inappropriate due to drug unavailability (43). Further, while evidence is mounting that the concomitant use of antibiotics does not have greater efficacy in the prevention of postsurgical infections (44), in a previous study conducted in Iran, 71.3% of the patients undergoing neurosurgical procedures inappropriately received a combination of two or more antibiotics (19). Additionally, in another study performed in Iran, the choice of antibiotic complied with guidelines in only 7.5% of the surgical procedures, which was considerably lower compared to our study results (16).

Therefore, despite the fact that clinical practice guidelines are developed to improve patient outcomes by decreasing variation in clinical practice and improving adherence to evidence-based care practices, adherence to clinical practice guidelines by surgeons is highly

variable and sub-optimal (18). The reasons for the low rate of adherence to guidelines appear to be complex and multifactorial and include fear of litigation, influence of initial training, lack of awareness of updated guidelines, personal preference, influence from colleagues, and lack of antibiotic policy implementation in the hospital (18,45). Thus, these pieces of evidence strongly highlight the need for effective strategies to enhance the rational use of preoperative antibiotic prophylaxis. One such strategy is the implementation of institutional guidelines. These guidelines have been designed to satisfy the needs of each institution based on the pattern of antimicrobial resistance, most common types of surgeries performed, and the availability of antibiotics (46); however, guidelines alone have been insufficient to change clinical practice (47). Educational interventions such as seminars and workshops emphasizing the proper practice should be conducted to improve the degree of adherence. Periodic auditing of surgical prophylaxis by the infection control team, provision of feedback, and implementation of formulary restriction are other strategies that can improve surgeons' adherence to guidelines for surgical antimicrobial prophylaxis (45). Involving pharmacists, especially clinical pharmacists, in monitoring the adherence to guidelines for antibiotic prophylaxis in surgery patients can also promote the rational use of antibiotic prophylaxis (9,48). However, at present, in most hospitals in Iran, pharmacists are not involved in controlling the irrational use of prophylactic antibiotics. Thus, in addition to pharmacists' attempts to enhance their clinical skills and therapeutic knowledge about the rational use of drugs to promote efficient and rational use of medicines in hospitals, the policies of the healthcare system also need to be shifted towards providing more opportunities for involvement of pharmacists in clinically advanced activities of the hospitals.

According to our results, practical measures to improve the appropriateness of antibiotic prophylaxis will be necessary for our hospital. In the first step, the results of our study will be discussed with the surgical teams, and efforts should be made to evaluate why the surgeons did not follow national guidelines. Developing institutional guidelines for surgical prophylaxis will be our next step in enhancing the rational use of preoperative antibiotic prophylaxis in our hospital. Assignment of a pharmacist, preferably a clinical pharmacist in a surgery department, continuous medical education programs for practitioners and other health care professionals, and frequent assessment of compliance with evidence-based guidelines will also be considered as other viable approaches for improving appropriate preoperative antibiotic prophylaxis. There is no doubt that the support and collaboration of hospital administrators and medical staff are essential for the implementation of these interventions.

It should be noted that this study had some limitations. The study was a cross-sectional type, and thus it did not investigate cause and effect relationships. Since it is a conveniently sampled observational study, selection bias may be introduced during sampling. Additionally, misclassification of the wound type may also be possible. We only included adult patients undergoing some major surgical procedures, so our findings may not apply to younger patients or those undergoing other operations. Furthermore, the exact timing of the intra-operative antimicrobial prophylaxis was assessed based on the anesthesiologists' notes on the anesthesia chart. Thus, we cannot guarantee the accuracy of recorded notes. Therefore, all these factors might have affected the outcomes, and future studies should take these variables into consideration.

Conclusion

Our survey demonstrated that the adherence of surgeons to antibiotic prophylaxis guidelines was inadequate in our hospital, and there is still considerable room for improvement, especially in the process of the discontinuation of antimicrobial prophylaxis. It seems that developing institutional guidelines for surgical prophylaxis is mandatory for enhancing the rational use of preoperative antibiotic prophylaxis in our hospital.

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Authors' Contribution

Conceptualization: Maryam Mehrpooya.
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Competing Interests

The authors report no conflict of interests in this work.

Ethical Approval

The present study was approved by the Ethics Committee of Hamadan University of Medical Sciences (IR.UMSHA.REC.1396.795).

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