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Evaluation of Ceftriaxone Utilization and Prescribing Patterns at Ibn Sina General Hospital, Yemen

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The improper use of antimicrobial agents is a major contributor to antibiotic resistance. Therefore, the initial step in addressing this issue is to assess the appropriateness of antibiotic use through drug utilization evaluation, a fundamental approach for ensuring proper medication use. This study aimed to assess the utilization of ceftriaxone in the wards of Ibn Sina Hospital. A retrospective cross-sectional study was conducted by reviewing the treatment records of 323 patients who received ceftriaxone during hospitalization between January 1 and December 31, 2017. Patient records were selected using a multistage random sampling method. Data were analyzed based on World Health Organization (WHO) criteria, which included indication, dosage, frequency, and treatment duration. Any deviation from these standards was classified as inappropriate use. The study found that ceftriaxone was administered to 44.48%, with males accounting for the majority of cases (69.4%). Overall inappropriate use of ceftriaxone was observed in 293 cases (90.8%). Misuse was more prevalent in surgical wards (98.4%) compared to medical wards (80.1%). Among the evaluated criteria, inappropriate indication was the most common issue, accounting for 66.9% of cases, followed by incorrect treatment duration (13.9%), while errors in dosage and frequency were equally observed at 5%. This study demonstrated a high rate of inappropriate ceftriaxone use, which could contribute to the development of resistant pathogens and ultimately result in treatment failure. Therefore, it is essential for prescribers to follow current evidence-based guidelines to ensure the rational use of antibiotics.

Keywords: Ceftriaxone Utilization; Drug Use Evaluation; Ibn Sina General Hospital; Inappropriate Prescribing; Yemen.

Antibiotics are one of the most common groups of drugs prescribed in hospitals. Improper prescribing and dispensing of antibiotics may result in their misuse and overuse, especially when healthcare professionals do not have access to the latest information. The overuse of antibiotics drives the evolution of antimicrobial resistance.[1] Ceftriaxone is a broad-spectrum third-generation cephalosporin antibiotic for intravenous or intramuscular administration. It is widely used and poses a relatively high risk of selecting resistant bacterial strains.[2, 3] Although antibiotics are

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essential in combating infectious diseases, their misapplication is widespread globally, often taking the form of unnecessary overuse.[4] For instance, excessive antibiotic use in treating acute respiratory infections in low- and middle-income countries increases healthcare expenses by approximately 36%.[5] Antimicrobial resistance (AMR) occurs when microorganisms develop resistance either through genetic mutations or by acquiring resistance genes via horizontal gene transfer mechanisms, such as plasmids, transposons, or integrons, after exposure to antimicrobial drugs.[6] While it naturally develops over time through genetic mutations, the acceleration of resistance is largely attributed to antibiotic overuse and inappropriate application.[7] The direct consequences of infections caused by resistant microorganisms include prolonged illness, higher mortality rates, extended hospitalization, compromised surgical safety, and increased healthcare costs.[8] Studies done in different hospitals in Yemen confirm that there is overprescribing and inappropriate use of antimicrobials. A prospective study by Al-Mehdar and Al-Akydy (2017) found that a significant proportion of inpatients at a teaching hospital in Yemen received antimicrobial prescriptions that did not align with standard treatment guidelines. Similarly, Bashrahil (2010) assessed rational drug use indicators in Hadramout and highlighted concerns regarding the overuse and misuse of antimicrobials in healthcare settings. [9, 10] These findings underscore the urgent need for antimicrobial stewardship programs to optimize prescribing practices and mitigate resistance development. Ceftriaxone is reported as the top frequently prescribed antibiotic in a study done in a teaching hospital in Yemen. However, due to its high resistance potential, ceftriaxone should be reserved as a first- or second-line treatment only for specific, well-defined indications, making it a priority for monitoring.[11] Data on the appropriateness of antibiotics use in hospitals is lacking in Yemen. On the other hand, the prevalence of antibiotic resistance at Ibn Sina General Hospital (ISGH) is too high, with a study by Al-Haddad and Abdo-Rabbo (2007) reporting significant resistance rates in isolated bacteria,[12] which confirms the urgent need to conduct studies that evaluate antibiotic use and provide details about the exact nature of irrational use and so interventions can be initiated to promote optimal antimicrobial therapy. Drug Utilization Evaluation (DUE) is a critical strategy for assessing medication use, as it provides a structured, criteria-based review of drug administration to ensure appropriate usage.[13, 14] Our study aims to examine the rationality of ceftriaxone use in the medical and surgical wards of ISGH. By identifying patterns of misuse such as unapproved indications, dosing errors, or contraindicated combinations the findings will inform interventions to optimize therapy, mitigate AMR risks, and improve patient outcomes in a high-burden setting.

MATERIALS AND METHODS

Study Design and period

A retrospective cross-sectional study was performed to assess ceftriaxone utilization by analyzing medical records of patients admitted at ISGH and who received ceftriaxone from 1 January to 31 December, 2017.

Study site

The study was conducted at ISGH, which is organized under the Ministry of Health. It provides medical and health services to patients in Hadhramout and neighboring governorates. This hospital provides diagnostic and treatment services for both outpatients and inpatients and is one of the largest healthcare facilities in Al-Mukalla city, serving as a clinical training site for medical and health sciences students. It includes intensive care units, outpatient clinics, medical, surgical, orthopedic, ophthalmic, and emergency departments.

Study population

Medical reports of all adult patients admitted at ISGH and received ceftriaxone during the study period. The hospital has a medical recording system with two colored reports. White reports are named “surgical reports” for patients admitted to surgical, ophthalmic, and orthopedic departments and surgical intensive care units, and green reports are named “medical reports” for patients who admitted at medical department and medical intensive care units. Out of a total of 7,089 patient treatment reports, 3,153 contained ceftriaxone, accounting for 44.48% of the reports.

The population consisted of 3,153 reports, with 1,328 (42%) being medical reports and 1,825 (58%) being surgical reports.

Sample size

The total sample size in this study was 323 medical and surgical reports for patients admitted at ISGH which is calculated based on the following formula:

$$N = \frac{(Z)^2 Pq}{(d)^2}$$

$$N = \frac{(1.96)^2 \times 0.3 \times 0.7}{(0.05)^2}$$

Where:

N= Required sample size

Z = The confidence interval (z = 1.96)

P = Proportion of the characteristic in the population (p = 0.3)

q=1-p (1-0.3= 0.7)

d= precision or error allowable (d = 0.05)

The sample was taken according to the ward proportions as follows:

Medical wards proportion (42%): 323 × 0.42 = 136 reports

Surgical wards proportion (58%): 323 × 0.58 = 187 reports

Sampling method

The sample was calculated by a multi-stages random sampling method regarding the following steps:

• First stage: The hospital records were categorized into two types—medical and surgical department reports. Both departments were selected for the study.

• Second stage: The total number of records for all adult patients who received ceftriaxone during the study period was determined. The 323 reports were then allocated proportionally to each department based on the total number of records.

• Third stage: The selection of patients from the selected department was based on a simple random method.

Study variables:

• Patient's data: Age and gender were recorded as basic demographic variables.

• Drug-related factors: These were categorized into usage indication (whether ceftriaxone was prescribed for an appropriate condition), dosage (appropriate versus inappropriate dosing), administration frequency (whether dosing intervals were in line with guidelines), treatment duration (whether the treatment duration was appropriate.

• Disease-related factors: These include the diagnosis (to assess the appropriateness of the treatment in relation to the patient's condition) and ward type (medical or surgical).

Inclusion and Exclusion Criteria

Inclusion Criteria

• Patients aged 18 years or older.

• Medical reports containing complete information.

Exclusion Criteria

• Medical reports with incomplete data.

• Patients with ambiguous diagnoses or multiple diagnoses

• Patients younger than 18 years.

Data collection

Data was collected by researchers through a review of treatment reports of patients admitted to ISGH during the study period from January 1 to December 31, 2017. A carefully structured patient data collection form was specifically designed for this study. The Drug Utilization Evaluation (DUE) criteria in this format were based on WHO guidelines for drug use evaluation and the *Manual for Drug and Therapeutics Committees: A Practical Guide.*

Data analysis

The collected data was input and analyzed using SPSS version 23. Descriptive statistics, including frequencies and proportions for numerical variables, were calculated, and a Chi-square test was performed. The analysis was conducted based on four criteria—usage indication, dosage, administration frequency, and treatment duration—following WHO guidelines for drug use evaluation and the Drug and Therapeutics Committee practical guide. WHO Model List of Essential Medicines (March 2017), British National Formulary (BNF 74), and Infectious Disease Society of America (IDSA) guidelines were utilized to validate the tool for assessing ceftriaxone use. Data has been presented by using tables and a comparison with other similar studies in various countries was done.

RESULTS

Demographics

Of the 323 patients, 99 (30.6%) were female and 224 (69.4%) were male. The majority of the cases (78.9%) were adults, aged 18 to 65 years, as presented in Table 1.

Appropriateness

Greater inappropriate use was observed in surgical wards (98.4 %) than in medical wards (80.1 %). Comparison between inappropriate ceftriaxone uses within different wards showed that medical wards had 100% appropriate use in terms of dose and frequency among the correct ceftriaxone indications. Both wards showed almost equal inappropriate percentages of indication (66.9 % and 66.8 % for medical and surgical wards respectively). Duration inappropriateness within correct indications was a little more in the surgical ward (14.4 %) than in the medical wards (13.2 %) as shown in Table 2. The overall inappropriateness of ceftriaxone use (including indication, duration, dose, and frequency) was 90.8%, according to the protocol established for its rational use. The highest proportion of inappropriate use was related to inappropriate indication (66.9%), followed by duration (13.9%), as shown in Table 2.

Inappropriate use in each category is defined as follows: Inappropriate Indication refers to the use of ceftriaxone when it is not clinically necessary, such as for viral infections or conditions that do not require antibiotic treatment; Inappropriate Dosage involves prescribing a dose that exceeds the recommended dosage based on the patient's age, weight, or renal function; Inappropriate Duration is administering ceftriaxone for a period longer than clinically indicated according to established guidelines for the specific condition; and Inappropriate Frequency involves administering ceftriaxone at intervals that do not align with the recommended dosing schedule for optimal therapeutic effect.

DISCUSSION

To identify inappropriate antibiotic use in hospitals, studies should be conducted to measure the problem and analyze it. For this reason, this study was conducted to assess the appropriateness of ceftriaxone use at ISGH. The results of this

Table 1. Age and Gender of Patients Included in the Study at ISGH

Ward	Gender				Age			
	Male		Female		Adult (18-65 years)		Geriatric (> 65 years)	
	Freq.	(%)	Freq.	(%)	Freq.	(%)	Freq.	(%)
Medical	81	25.1	55	17.0	76	23.5	60	18.6
Surgical	143	44.3	44	13.6	179	55.4	08	02.5)
Sum	224	69.4	99	30.6	255	78.9	68	21.1
Total	100 %				100 %			

Table 2. Inappropriateness of Ceftriaxone Uses within Different Wards at ISGH

Criteria	Medical		Surgical		Inappropriate	Inappropriateness
	Freq.*	(%)	Freq.	(%)	Freq.	(%)
Indication	91	66.9	125	66.8	216	66.9
Duration	18	13.2	27	14.4	45	13.9
Dose	0.0	0.0	16	8.6	16	05.0
Frequency	0.0	0.0	16	8.6	16	05.0
Overall inappropriateness	109	80.1	184	98.4	293	90.8

* Freq.= Frequency.

study indicate a significant level of inappropriate ceftriaxone utilization at Ibn Sina General Hospital (ISGH), with an overall inappropriateness rate of 90.8%. This finding aligns with previous studies conducted in various contexts, highlighting a broader issue of ceftriaxone misuse globally. The study found that 66.9% of ceftriaxone prescriptions were for inappropriate indications, a rate consistent with findings from similar studies. For instance, a study in Ethiopia reported inappropriate indications in 56.3% of cases,[15] while another study in Korea indicated that inappropriate indications accounted for 42.8%.[16] Several factors may explain these discrepancies. Differences in hospital protocols and the strictness of antibiotic stewardship programs could play a role, as hospitals with more rigid guidelines and better surveillance may have lower rates of inappropriate prescriptions. Additionally, variations in diagnostic resources, such as the availability of timely culture and sensitivity testing, may influence the extent of empirical prescribing, which is more common in settings with limited diagnostic capabilities. The pressure to prescribe empirically, especially in busy hospital settings, may contribute to the higher rates of inappropriate indications observed in our study.[17, 18] The duration of ceftriaxone treatment was inappropriate in 13.9% of cases. This is notably lower than reports from Gondar University Hospital in Ethiopia,[19] where the inappropriate duration was reported at 47%. While the shorter treatment durations observed in our study may reflect a trend toward more aggressive management in surgical settings, where prophylactic antibiotic use is common, other factors may also contribute. In some healthcare settings, shortening antibiotic treatment durations can be a cost-reduction strategy, particularly in resource-limited hospitals where prolonged therapy may not be financially sustainable. Additionally, some institutions may implement policies favoring shorter antibiotic courses to minimize unnecessary antibiotic exposure, potentially reducing the risk of antimicrobial resistance. However, if not guided by clear clinical guidelines, these practices may lead to suboptimal treatment outcomes. Furthermore, prescriber habits and perceptions about the sufficiency of shorter antibiotic courses, coupled with inadequate follow-up of treatment effectiveness, may also contribute to inappropriate treatment durations.[20] In terms of dosing, the study found that 5% of cases had inappropriate doses. This finding is similar to reports from Tikur Anbessa Hospital,[21] where the inappropriate dosing was noted at 5.7%. A lack of standardization in dosing protocols can lead to variations in patient outcomes and contribute to resistance development. Furthermore, the frequency of administration was also identified as inappropriate in 5% of cases, which aligns with findings from a study in Dessie, Ethiopia, where the inappropriate frequency was reported at 24%.[22] The analysis revealed that gender was significantly associated with inappropriate ceftriaxone use, as found in previous studies.[15] Gender differences in inappropriate ceftriaxone use may be influenced by variations in disease prevalence, healthcare-seeking behaviors, and prescriber tendencies. Certain infections requiring ceftriaxone may be more common in one gender, affecting prescribing patterns, while differences in healthcare access and treatment-seeking behaviors could also play a role. Additionally, prescriber perception and potential bias may lead to differing prescribing tendencies based on assumptions about treatment adherence or illness severity. Furthermore, variations in comorbidities and risk factors may contribute, as one gender may be more likely to present with conditions that necessitate empirical ceftriaxone use. However, age did not demonstrate a significant association, contrasting with findings from a comparative study in Addis Ababa where age was a significant factor.[23] This discrepancy may arise from differences in patient demographics and treatment practices across hospitals. While inappropriate ceftriaxone use was predominantly linked to empirical prescribing and lack of adherence to guidelines, other factors may contribute. Limited diagnostic resources, prescriber habits, and institutional protocols could play a role in decision-making. Additionally, variations in antimicrobial resistance patterns across regions may influence prescribing behaviors.

CONCLUSION

Ceftriaxone, a widely used antibiotic at ISGH, showed a high rate of inappropriate utilization, particularly in surgical prophylaxis and complicated intra-abdominal infections.

Incorrect indications and duration were the primary contributors to misuse, increasing the risk of resistant bacterial strains, treatment failure, and higher healthcare costs. Additionally, prescriber adherence to international guidelines was notably poor, highlighting the need for Drug and Therapeutics Committee interventions, which were lacking at ISGH. This study has limitations, including its retrospective design and reliance on medical records, which may have incomplete data. Additionally, the findings are specific to ISGH and may not fully represent other healthcare settings. Future research should focus on prospective studies to assess real-time prescribing behaviors and evaluate the impact of targeted antimicrobial stewardship programs on improving ceftriaxone use.

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Conflict of Interest

The author(s) do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

The procedures for this study included obtaining permission letters from the Department of Community Medicine at the College of Medicine and Health Sciences, Hadhramout University. In addition, an informed agreement was obtained from the management of Ibn Sina General Hospital (ISGH).

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Clinical Trial Registration

This research does not involve any clinical trials

Permission to reproduce material from other sources

Not Applicable

Author Contributions

Tareq Maqlam: Conceptualization, Methodology, and Writing – Original Draft; Abdullah Hameed Maad: Data Collection, Analysis, and Writing – Review & Editing; Farid Ali Bagail: Methodology, and Data Collection; Anwar Mohsen Alhaj: Data Collection, and Writing– Review.

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