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Analysis of Adverse Reactions Caused by Antibiotics and Rational Drug Use in Clinical Practice

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Abstract: *Objective:* To explore the adverse reactions associated with antibiotics and analyze strategies for their rational use. *Methods:* A retrospective analysis was conducted on 60 patients who experienced adverse reactions to antibiotics between August 2021 and August 2023. The types of antibiotics that caused adverse reactions were analyzed, and the symptoms of adverse reactions and measures for rational use of antibiotics were summarized. *Results:* Among the analyzed cases of adverse reactions to antibiotics, the highest rate was observed in patients aged 61–75 years, accounting for 38.33%, followed by patients aged 51–60 years, accounting for 20.00%. In terms of the types of antibiotics that caused adverse reactions, cephalosporins were the most common, accounting for 40.00%, followed by penicillins, accounting for 18.33%. Analysis of the systems involved in adverse reactions showed that skin and appendage disorders were the most common, accounting for 36.67%, followed by the digestive system, accounting for 28.33%. *Conclusion:* Irrational use of antibiotics can lead to adverse drug reactions. Therefore, it is necessary to analyze strategies for the rational use of antibiotics to reduce adverse drug reactions and ensure the safety of antibiotic use.

Keywords: Antibiotics; Rational drug use; Adverse reactions

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1. Introduction

Antibiotics refer to secondary metabolic substances produced during the life processes of pathogenic bacteria, plants, or animals. They exhibit anti-pathogen activity or other active characteristics and are widely used in the treatment of diseases caused by infectious pathogens, with excellent efficacy [1]. However, with the continuous enrichment of antibiotic types, the rate of irrational antibiotic use has increased, resulting in drug-related adverse reactions in some patients treated with antibiotics. These adverse reactions can damage the skin and cause dysfunction of multiple systems such as respiratory, nervous, digestive, and cardiovascular systems, and even lead to death [2]. Therefore, it is necessary to conduct an in-depth analysis of antibiotic use, identify issues with irrational antibiotic use, and explore targeted solutions. In this study, 60 patients who experienced adverse reactions to antibiotics between August 2021 and August 2023 were selected as samples to investigate the adverse

reactions and summarize strategies for rational drug use.

2. Materials and methods

2.1. Materials

A retrospective analysis was conducted on the data of 60 patients who experienced adverse reactions to antibiotics between August 2021 and August 2023. Among them, 34 were males and 26 were females, with an age range of 12 to 73 years and a mean age of (44.26 ± 3.25) years. Patients and their families provided informed consent for the use of antibiotic treatment. At the time of enrollment, patients had no organ lesions or cardio-cerebrovascular diseases.

2.2. Methods

A retrospective analysis of case data was performed to collect information on the types of adverse reactions, categories of antibiotic drugs, and general data of patients taking the medications. A comprehensive analysis of rational drug use strategies was conducted.

(1) The adverse reactions were analyzed based on age, and the adverse reaction rates were calculated for different age groups.

(2) The adverse reactions were analyzed based on drug categories, and the adverse reaction rates were calculated for different types of drugs.

(3) The adverse reaction symptoms were analyzed, and the incidence rates of different system lesions were calculated.

2.3. Statistical analysis

The data were processed using SPSS 21.0 software. Chi-square test and percentage (%) were used to describe counting indicators, while the t-test and mean ± standard deviation (±s) were used to describe measurement indicators. Statistical significance was set at $P < 0.05$.

3. Results

3.1. Analysis of adverse reactions to antibiotics

The analysis of adverse reactions to antibiotics showed that the highest adverse reaction rate occurred in the age group of 61–75 years, accounting for 38.33%, followed by the age group of 51–60 years, accounting for 20.00%. The results are presented in **Table 1**.

Table 1. Analysis of adverse reactions to antibiotics (n,%)

Age	Number of Cases	Incidence Rate
12–20 years old	9	15.00
21–30 years old	9	15.00
31–40 years old	3	5.00
41–50 years old	4	6.67
51–60 years old	12	20.00
61–75 years old	23	38.33

3.2. Analysis of types of antibiotic drugs

An analysis of the types of antibiotic drugs that caused adverse reactions showed that cephalosporins were the most common, accounting for 40.00%, followed by penicillins, accounting for 18.33%. The results are presented in **Table 2**.

Table 2. Analysis of types of antibiotic drugs (n,%)

Type of Antibiotics	Number of Cases	Incidence Rate
Cephalosporins	24	40.00
Penicillins	11	18.33
Macrolides	7	11.67
Aminoglycosides	6	10.00
Quinolones	6	10.00
Tetracyclines	6	10.00

3.3. Analysis of systems involved in adverse reactions

An analysis of the systems involved in adverse reactions showed that skin and appendage disorders were the most common, accounting for 36.67%, followed by the digestive system, accounting for 28.33%. The results are presented in **Table 3**.

Table 3. Analysis of systems involved in adverse reactions to antibiotics (n,%)

Affected system	Number of cases	Incidence rate
Skin and Appendages	22	36.67
Digestive System	17	28.33
Nervous System	10	16.67
Respiratory System	6	10.00
Cardiovascular System	5	8.33

3. Discussion

Antibiotics have been widely used in clinical treatment to fight pathogens in humans or animals, and are suitable for diseases caused by microbial infections [3]. However, selecting the appropriate antibiotic for treatment remains a hot topic in clinical research, as it aims to ensure efficacy while reducing adverse drug reactions. During clinical treatment, improper use of antibiotics can damage patients' physiological functions and even pose a threat to their lives. To summarize, common adverse drug reactions during antibiotic treatment are as follows:

(1) Allergic reactions

(a) Shock: For example, some patients may experience an allergic reaction when taking cephalosporins, and severe cases can lead to shock. Therefore, before selecting cephalosporins, patients should undergo a sensitivity test to ensure they are not allergic to the medication.

(b) Anemia: The most common type is hemolytic anemia, characterized by a decrease in blood cell count.

(c) Drug-induced fever and serum sickness: Manifestations include joint pain, edema, and high fever.

(d) Others: During treatment with tetracyclines and penicillins, apart from the aforementioned common adverse reactions, unclassified allergic symptoms such as erythroderma, erythema, and urticaria may also occur.

(2) Toxic reactions

Different types of antibiotics can cause different toxic reactions, especially those with a low therapeutic index, which have a higher rate of adverse reactions. Additionally, among various antibiotic toxic reactions, neurotoxicity such as nerve function impairment has a higher incidence.

(3) Idiosyncratic reactions

Patients taking antibiotics may develop idiosyncratic reactions, although the incidence is low. The inducement of these reactions is associated with multiple factors such as genetics and constitution. Antibiotics that are prone to cause idiosyncratic reactions mainly include benign mycin and chloramphenicol, as their components can exert effects within red blood cells, thereby affecting the body's metabolism.

(4) Re-infection reactions

Excessive or prolonged use of antibiotics can affect their efficacy, limiting their antibacterial effect and failing to inhibit bacterial reproduction, thus increasing the risk of reinfection [4]. In clinical cases where irrational use of antibiotics leads to reinfection, the antibiotics are mainly broad-spectrum antibiotics. Furthermore, excessive use of antibiotics can also disrupt the balance of the patient's internal flora, further affecting the efficacy of the medication.

Based on the data analysis in this study, the highest adverse reaction rate was observed in the 61–75 age group, accounting for 38.33%, followed by the 51–60 age group at 20.00%. This suggests that adverse reactions to antibiotics are not uncommon during clinical treatment, and among patients aged 13–75, the elderly population is more prone to adverse drug reactions. This is attributed to factors such as:

(1) Degenerative changes in liver and kidney function in the elderly, which can affect drug metabolism and excretion, leading to altered pharmacokinetic parameters. Long-term medication use can result in drug accumulation, triggering adverse effects.

(2) Reduced drug sensitivity in the elderly, as the body's sensitivity to medications decreases with age. Therefore, increased drug dosages and prolonged treatment durations can increase the risk of adverse reactions.

(3) The presence of multiple comorbidities requiring concomitant use of various medications, which may interact with each other, elevating the risk of adverse drug reactions.

(4) Poor stability of the elderly's bodily functions, making them more susceptible to adverse reactions under the influence of exogenous factors such as medications. Another set of data indicates that cephalosporins were the most common type of antibiotics causing adverse reactions, accounting for 40.00%, followed by penicillins at 18.33%.

The reasons for these adverse reactions include: (a) Allergic reactions such as skin rashes and shock; (b) Hepatorenal toxicity symptoms like disordered liver and kidney function; (c) Gastrointestinal symptoms including discomfort, nausea, and vomiting; (d) Disulfiram-like reactions manifesting as hypotension and flushing. The final set of data reveals that skin and appendage disorders were the most common system involved in adverse reactions, accounting for 36.67%, followed by the digestive system at 28.33%. Skin and appendage disorders are often related to irritation from the active ingredients, such as the presence of allergens that trigger immune responses,

leading to skin irritation manifesting as redness, bumps, and itching. Patient's own allergic constitution is also a factor. Adverse reactions in the digestive system can be attributed to: (a) Stimulation by active ingredients, such as taking medications that stimulate gastric acid secretion, which can cause gastrointestinal reactions like nausea and vomiting; (b) Dietary influences, such as consuming spicy, cold, or greasy foods during medication, which can increase the burden on the stomach and intestines, slow down gastrointestinal motility, and induce indigestion; (c) Psychological factors, where patients may experience prolonged anxiety and stress due to their illnesses, activating the sympathetic nervous system and leading to indigestion [5].

Therefore, medical institutions should properly manage antibiotic control, conduct in-depth analysis of patient data on adverse reactions caused by antibiotics, standardize antibiotic use from the source, and reduce irrational antibiotic use to minimize adverse drug reactions. Based on a summary analysis, adverse antibiotic reactions can be reduced in the following ways:

(1) Condition analysis

Before starting antibiotic treatment, it is essential to comprehensively analyze the patient's physical state and carefully study their medical history, medication history, allergy history, and other relevant information. Additionally, patients should be guided to undergo relevant examinations, and symptoms of antibiotic discomfort, types of pathogenic bacteria, antimicrobial spectrum, and infection location should be recorded. Safe and efficient drugs should be selected to ensure the antibacterial and bacteriostatic effects of antibiotics.

(2) Strict control of indications

When selecting antibiotic drugs, physicians and pharmacists should strictly control the indications for antibiotics, choosing drugs based on the patient's symptoms, condition, and bacterial test results to increase the blood drug concentration in the target tissue and enhance the efficacy of the medication. For patients with potential allergic risks, drug sensitivity tests should be actively carried out to avoid adverse drug reactions as much as possible.

(3) Improving the review system

After a physician issues an antibiotic prescription, a pharmacist should review the prescription, comprehensively understand the patient's disease condition, evaluate the rationality of the prescription, and focus on reviewing the type, dosage, and precautions of antibiotics. Once the prescription is approved, antibiotic drugs can be dispensed to the patient. During the dispensing process, medical staff should repeatedly emphasize the importance of following medical advice on medication use, patiently inform patients about the dosage and frequency of medication, and provide instructions on correct medication methods. Patients should also be advised to observe any physical discomfort or adverse reactions during medication and report them immediately. The physician can then redevelop the treatment plan to ensure the safe use of antibiotics.

(4) Principles of combined antibiotic use

When two or more antibiotics are used in combination, they can have a synergistic effect and enhance efficacy. However, it is essential to pay attention to the antimicrobial spectrum characteristics of the combined drugs, master the indications for combination therapy, and avoid negative reactions between different drugs. In clinical practice, when a single antibiotic is not effective in antibacterial treatment, combination therapy can be used to enhance efficacy, such as in the treatment of severe or mixed infections.

(5) Principles of antibiotic dosage control

Compared to other clinical therapies, antibiotic drugs have more drug-resistant strains and fewer adverse reactions. Therefore, during combined drug administration, the type of antibiotic should be selected based on the patient's infection site and disease progression, and the antibiotic dosage should be reasonably planned to avoid problems such as low blood drug concentration due to too small a dosage or toxic reactions due to too large a dosage, thereby enhancing the efficacy of antibiotics and optimizing the patient's prognosis.

(6) Principles of antibiotic administration time and route control

To ensure the efficacy of antibiotics, patients should be provided with sufficient medication, and the route of administration and time interval between administrations should be clarified. For example, when using medium-efficacy sulfonamides, medication should be discontinued for one day after one day of use, with a time interval of one day between administrations. If the time interval is too long, the medicinal effect cannot be maintained. Additionally, when using cephalosporins and penicillins for sterilization, the active ingredients are quickly absorbed and can reach the expected blood drug concentration in a short period, exerting a bactericidal effect. Moreover, the half-life of penicillin drugs is about 0.7 hours, and the metabolic rate of active ingredients is about 90% after 3–4 hours of administration. After 6 hours, the blood drug concentration in the body is no longer effective in antibacterial activity, i.e., it is below the minimum inhibitory blood drug concentration [6]. Therefore, when using penicillin drugs, intermittent administration should be followed according to medical advice, with a recommended frequency of 2–3 times per day.

(7) Implementation of reward and punishment measures

Medical institutions should regularly conduct spot checks on antibiotic prescriptions, summarize the frequency of antibiotic drug use, and evaluate whether prescriptions comply with clinical antibiotic use rules based on clinical diagnosis, frequency of medication, and dosage. Additionally, the proportion of various antibiotic drugs should be counted, and case information and symptoms of adverse reactions of patients with antibiotic adverse reactions should be summarized. Departments that use antibiotics rationally should be rewarded, and departments that use antibiotics irrationally should be criticized and notified to stimulate the sense of responsibility of medical staff and improve the rational use of antibiotics.

(8) Opening an antibiotic medication consulting hotline

Professional personnel should be assigned to answer the hotline, patiently answer patients' medication questions, and guide patients to deeply understand the precautions and medication plans for antibiotic use. They should also inquire whether patients experience any discomfort to reduce irrational antibiotic use [7]. However, it is important to note the following during antibiotic treatment: (a) Adequate medication: During antibiotic use, patients should follow medical advice and take adequate dosages. Otherwise, if the dosage is too low, it may not kill the bacteria, leading to disease recurrence and prolonging the patient's course of disease. (b) Avoiding self-discontinuation: Patients should not stop taking antibiotic drugs by themselves even if their condition improves. Otherwise, it may lead to disease recurrence and affect drug efficacy.

4. Conclusion

In summary, adverse reactions to antibiotics occur frequently during antibiotic use, especially among the elderly population. Cephalosporins and penicillins are more prone to adverse reactions, with a high proportion of skin and appendage reactions and digestive system reactions. Therefore, it is crucial to explore rational drug use strategies to enhance the safety of antibiotic use.

Disclosure statement

The authors declare no conflict of interest.

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