Analysis on the Use of Special Use Level of Antibiotics among Inpatients in a Hospital

Yufen XIA, Wen PENG, Fan FENG, Liang YANG, Ying LIN*

The Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine, Guiyang 550001, China

Abstract [**Objectives**] This study was conducted to promote the rational use of special use level of antibiotics in clinic and delay the emergence of drug resistance. [**Methods**] The application of antibiotics for special use among inpatients of a hospital in 2019 was analyzed. The data in the drug information management system of the hospital were queried, and the collected expert consultation records of special-use antibiotics were sorted out. Indicators including the use rate of special-use antibiotics, antibiotic use density (AUD), defined daily dose system (DDDs) and defined daily dose system cost (DDDc) of each drug, the annual pathogen detection rate, disease distribution and pathogenic microorganism detection were summarized and analyzed for inpatients in the hospital retrospectively. [**Results**] In 2019, the average annual use rate of special-use antibiotics in the hospital was 1.53%, and the average annual use density was 1.59 DDDs. The antibiotics with the top three DDDs were imipenem and cilastatin, meropenem and cefepime. The antibiotics with the top three DDDc were voriconazole dispersible tablets, voriconazole for injection, and meropenem for injection. The average annual detection rate of microorganisms was 85.77%. The diseases were mainly diagnosed as respiratory infections such as pneumonia and secondary infections after radiotherapy and chemotherapy before medication, and the detected pathogens were mainly *Candida* and its subspecies, *Escherichia coli*, and *Klebsiella* and its subspecies. [**Conclusions**] The clinical use of special-use antibiotics in the hospital was basically reasonable, but there were still some problems. It is necessary to increase management efforts, strengthen training for relevant medical personnel, and provide management ideas for further standardizing the use of antibiotics in the hospital.

Key words Antibiotics; Special use level; Rational use of drugs; Antibiotic use density; Defined daily dose system; Microbial inspection

DOI:10.19759/j.cnki.2164-4993.2025.01.012

Special use level antibiotics are considered to be the most effective way to treat infection of drug-resistant bacteria, but with unreasonable clinical use, the drug resistance of special use level antibiotics is becoming more and more serious. The published results of research on monitoring of drug resistance to bacteria[1-3] reveal that the resistance rate of *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* to carbapenem drugs such as imipenem and meropenem is on the rise, and *Acinetobacter* is even highly resistant to these drugs. Therefore, we should analyze the current situation of the use of special-use antibiotics[4-6], strengthen pharmaceutical intervention and supervision, and gradually standardize the rational use of these drugs in clinic, so as to delay the process of resistance to carbapenem drugs.

In this study, the medical records of inpatients who used special use level antibiotics in a hospital from January to December, 2019 were reviewed to investigate indicators including monthly use rate, antibiotic use density (AUD), defined daily dose system (DDDs), and microbial detection rate, and problems existing in clinical application were analyzed, aiming to provide reference for intervention, guidance and supervision of rational use of clinical special-use antibiotics.

Received: November 9, 2024 Accepted: January 12, 2025

Supported by National TCM Advantage Speciality Construction Project: Clinical Pharmacy (GZYYYZH[2024]90); Guizhou Provincial Key Discipline Construction Project of Traditional Chinese Medicine and Ethnic Medicine: Clinical Traditional Chinese pharmacy (QZYYZDXK(JS)-2023-04).

Yufen XIA (1988 -), female, P. R. China, pharmacist-in-charge, devoted to research and development of hospital pharmacy and hospital preparations.

* Corresponding author.

Information and Methods

Data acquisition

The medical records of special-use antibiotics in various departments from January to December, 2019 were accessed from the HIS system of the hospital, including case information, drug name, usage and dosage. The clinical consultation sheets of special-use antibiotics in all departments throughout the year were collected from the Western medicine pharmacy in this hospital.

Computing method

Excel 2019 was employed to summarize and screen all the data and make statistical analysis.

Investigated indexes

(1) The monthly use rate of special-use antibiotics represents the proportion of patients who use special antibacterial drugs to the total number of patients in a certain period of time. It was calculated according to following formula: Monthly use rate of special-use antibiotics = Number of people discharged from a hospital using special antibacterial drugs every month/Number of people discharged from the hospital in the same period. This index is an important measure of the use of special-use antibiotics in medical institutions.

(2) The antibiotic use density (AUD) for special-use antibiotics indicates the cumulative consumption of special-use antibiotics (cumulative DDDs) per 100 people per day in a certain period of time. The AUD for special-use antibiotics in each month was calculated according to following formula: Monthly antibiotic use density (AUD) for special-use antibiotics = Cumulative DDDs × 100/Number of hospitalization days of inpatients in the same period. The use density of antibiotics for inpatients in medical institutions should be controlled below 40 DDDs, and there is no special requirement for the use density of special-use antibiotics.

(3) Defined daily dose system (DDDs) reflects the using

frequency of a drug in clinic. The DDDs of each drug was calculated according to following formula: Defined daily dose system of a drug (DDDs) = Total consumption of the drug/Defined daily dose (DDD) of the drug recommended by WHO. A greater DDDs value indicates that the drug is used more, and the tendency for selection of the drug in clinic is higher.

(4) Defined daily dose cost (DDD_C) reflects the price of a drug and represents the average daily cost for patients using the drug. The DDD_C of each drug was calculated according to following formula: Defined daily dose cost (DDD_C) of a drug = Annual sales amount of the drug/DDDs of the drug. A greater DDDC value indicates heavier economic burden for patients.

(5) Pathogen inspection indexes: Microbial detection rate of special-use antibiotics, Detection rate = Number of cases submitted for detection/Number of cases using special-use antibiotics in the same period × 100%; distribution of infectious diseases before medication in the cases submitted for detection; detection of pathogens.

Results and Analysis

General situation

The main varieties used were imipenem-cilastatin, cefepime, aztreonam, meropenem, vancomycin, linezolid, tigecycline-like substances, amphotericin, micafungin, voriconazole for injection and voriconazole dispersible tablets. In 2019, there were 478 cases of patients using special-use antibiotics in the hospital, including 291 cases of males, accounting for 61%, and 186 cases of females, accounting for 39%. The youngest case was 11 years old, and the oldest was 96 years old, and the average age was 65 years old. Among them, there were 38 people in the age group under 30 years old, accounting for 8%, 129 people in the age group of 30 – 60 years old, accounting for 27%, and 311 people over 60 years old, accounting for 65%.

Monthly use rate and use density of special-use antibiotics

The use rate of antibiotics for inpatients in the hospital was between 37% and 45% every month, with an annual average of 39.81%, which met the requirement that the use rate of antibiotics for inpatients in medical institutions should not exceed 60%. The annual use density of special-use antibiotics ranged from 1.14 – 2.35 DDDs. In specific, February, August and December ranked the top three, and the annual average was 1.59 DDDs, as shown in Table 1, Fig. 1, Fig. 2 and Fig. 3.

Table 1 Use rate and use density of special-use antibiotics in various months

Month	Number of inpatients in the same period	Number of people using antibiotics	Use rate of antibiotics %	Number of inpatients using special-use antibiotics	Use rate of special-use antibiotics//%	Number of hospitalization days of inpatients in the same period//d	Cumulative DDDs of special-use antibiotics	Antibiotic use density (AUD)
Jan.	2 966	1 240	41.81	48	1.62	36 727	616.99	1.68
Feb.	2 144	971	45.29	40	1.87	26 144	480.68	1.84
Mar.	3 252	1 359	41.79	47	1.45	40 747	526.15	1.29
Apr.	3 135	1 204	38.41	51	1.63	39 146	616.02	1.57
May	3 055	1 187	38.85	57	1.87	37 501	625.53	1.67
Jun.	3 039	1 147	37.74	43	1.41	38 067	434.04	1.14
Jul.	3 274	1 274	38.91	42	1.28	40 195	517.46	1.29
Aug.	3 230	1 212	37.52	53	1.64	38 910	752.29	1.93
Sep.	3 049	1 194	39.16	49	1.61	36 782	513.72	1.40
Oct.	2 812	1 133	40.29	40	1.42	33 531	496.12	1.48
Nov.	3 032	1 185	39.08	34	1.12	36 453	557.39	1.53
Dec.	3 040	1 235	40.63	46	1.51	36 308	852.35	2.35
Whole year	36 028	14 341	39.81	550	1.53	440 511	6 988.74	1.59

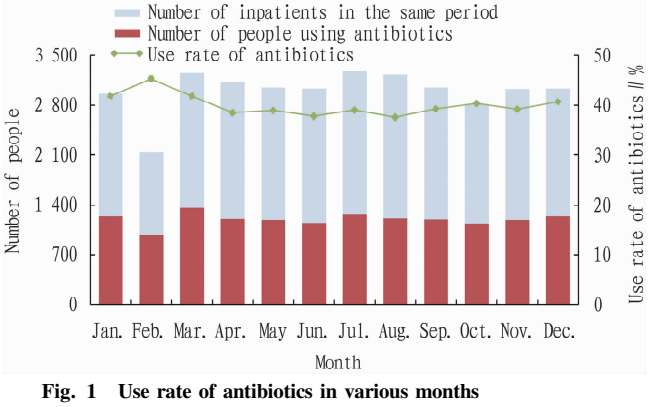

Fig. 1 Use rate of antibiotics in various months

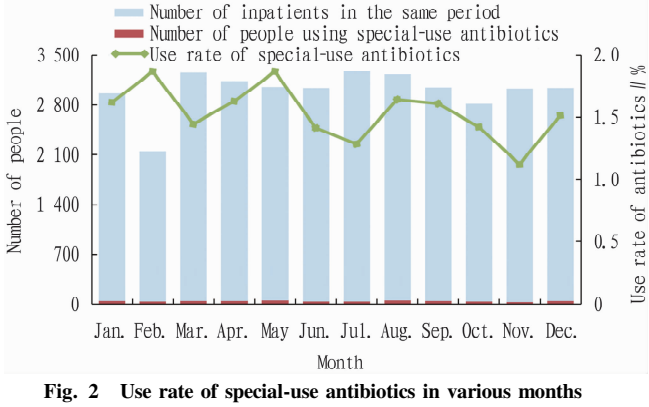

Fig. 2 Use rate of special-use antibiotics in various months

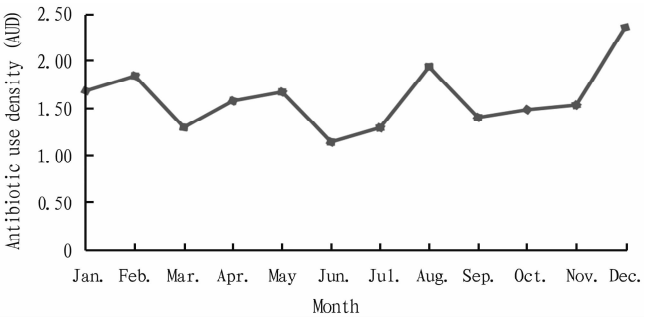

Fig. 3 Use density of special-use antibiotics in various months

Defined daily dose system and defined daily dose cost of various special-use antibiotics

In 2019, antibiotics with the top three DDDs in the hospital were imipenem and cilastatin sodium for injection, meropenem for injection, and cefepime for injection, which showed a greater tendency of clinical use. Antibiotics with the top three DDDc were voriconazole dispersible tablets, voriconazole for injection, meropenem for injection, all of which cost more than 1 500 yuan, and thus put heavier economic burden on patients. The specific data are shown in Table 2.

Table 2 Comparison on DDDs and DDDc of special-use antibiotics

Name	DDD	Defined daily dose system		Defined daily dose cost//yuan	
		DDDs	Rank	DDDc	Rank
Imipenem and cilastatin sodium for injection	2.00	4 130.50	1	193.24	9
Vancomycin hydrochloride for injection	2.00	497.00	4	455.88	7
Micafungin sodium for injection	0.15	127.00	8	1 431.00	4
Tigecycline for injection	0.10	170.50	7	900.00	5
voriconazole dispersible tablets	0.40	80.50	10	3 040.00	1
voriconazole for injection	0.40	83.00	9	2 058.28	2
Aztreonam for injection	4.00	35.25	12	91.60	11
Linezolid and glucose injection	1.20	175.50	6	746.05	6
Amphotericin B liposome for injection	0.04	200.00	5	441.63	8
meropenem for injection	3.00	803.17	2	1 586.94	3
Cefepime hydrochloride for injection	2.00	80.50	10	80.00	12
Cefazoxime sodium for injection	4.00	629.81	3	118.93	10

Detection of pathogens throughout the year

Detection rates of cases using special-use antibiotics In this study, 478 cases using special-use antibiotics were sorted out, and 410 cases among them were submitted for detection of pathogenic microorganisms. The average annual detection rate was 85.77%, which met the requirements of special-use antibiotics for pathogen detection. Statistical analysis of the monthly detection showed that the detection rates in March and October were lower, and the detection rates in other months were basically up to standard, as shown in Table 3.

Table 3 Detection of pathogenic microorganisms in each month

Month	Number of cases submitted for inspection	Cases using special-use antibiotics in the same period	Detection rate//%
Jan.	36	42	85.71
Feb.	31	34	91.18
Mar.	29	41	70.73
Apr.	39	45	86.67
May	48	51	94.12
Jun.	30	37	81.08
Jul.	30	36	83.33
Aug.	43	47	91.49
Sep.	39	43	90.70
Oct.	27	34	79.41
Nov.	25	28	89.29
Dec.	33	40	82.50
All year	410	478	85.77

Distribution of diseases in inspection sheets Among the 410 inspection sheets, the infection before medication was mostly diagnosed as respiratory pneumonia and related diseases, accounting for 51.95%, followed by infection after tumor radiotherapy and chemotherapy, accounting for 21.23%. The third type was infection caused by circulatory system diseases, accounting for 11.71%. The data are shown in Table 4.

Distribution of detected pathogenic microorganisms Among the 410 cases submitted for inspection, 154 cases were confirmed to have the results of pathogenic microorganisms and drug sensitivity, accounting for 37.56%. The top three pathogens were *Candida* and its subspecies, *Escherichia coli*, *Klebsiella* and its subspecies, and the antibiotics were changed for some cases according to the results of pathogen detection. The results are shown in Table 5.

Conclusions and Discussion

Conclusions

The results showed that the use of special-use antibiotics for inpatients in this hospital in 2019 was basically reasonable. The use rate of antibiotics was 39.81%, and the average annual use rate of special-use antibiotics was 1.53%, which met the requirement that the use rate of antibiotics in inpatients is lower than or equal to 60%. The antibiotic use density was 1.59 DDDs, and the microbial inspection rate was 85.77%, which met the national requirements. Most of the diseases diagnosed before medication were respiratory infection such as pneumonia and secondary infection after radiotherapy and chemotherapy. The pathogens detected were

mainly *Candida* and its subspecies, *E. coli*, *K. pneumoniae* and its subspecies, and *Acinetobacter baumannii*. In clinic, the hospital prefers to choose imipenem and cilastatin, meropenem and cefepime. However, the defined daily dose cost of voriconazole and meropenem is higher, which indicates that the economic burden of patients will be heavier.

Table 4 Distribution of diseases in inspection sheets

Infection site	Diagnosis	Cases	Proportion//%	Cumulative proportion//%
Respiratory system	Respiratory failure	32	7.80	51.95
	Lung infection	36	8.78	
	CAP, severe pneumonia	89	21.71	
	COPD pneumonia	56	13.66	
Tumor radiotherapy and chemotherapy	Right cheek mass	2	0.49	21.23
	Secondary infection after tumor chemotherapy	27	6.59	
	Leukemia infection	49	11.95	
	Agranulocytosis	9	2.20	
Circulatory system	Intracranial infection	4	0.98	11.71
	Septicopyemia	28	6.83	
	Septic shock	13	3.17	
	Cerebral infarction hemorrhage complicated with infection	2	0.49	
	Lupus encephalopathy	1	0.24	
Others	Urinary tract infection	6	1.46	7.80
	Acinetobacter baumannii	2	0.49	
	Diabetic foot	2	0.49	
	Infection of negative *Escherichia coli* subspecies	1	0.24	
	Surgical incision of hip joint, waist, *etc.*	6	1.46	
	Aspergillus	1	0.24	
	Others	14	3.42	
Digestive system	Intestinal and biliary tract infection	29	7.07	7.31
	Severe pancreatitis	1	0.24	

Table 5 Detection of pathogenic microorganisms

Name of microorganism	Number of detected cases	Distribution proportion//%
Candida and its subspecies	27	6.59
Escherichia coli	22	5.37
Klebsiella and its subspecies	21	5.12
Acinetobacter baumannii	16	3.90
Staphylococcus aureus and its subspecies	13	3.17
Pneumococcus and its subspecies	12	2.93
Pseudomonas aeruginosa	10	2.44
Enterococcus faecium	9	2.20
Other miscellaneous bacteria	8	1.95
Enterobacter cloacae and its subspecies	4	0.98
Proteus vulgaris	3	0.73
Stenotrophomonas maltophilia	2	0.49
Corynebacterium striatum	1	0.24
Raoultella planticola	1	0.24
Acinetobacter haemolyticus	1	0.24
Nocardia	1	0.24
Elizabethkingia meningoseptica	1	0.24
Listeria monocytogenes	1	0.24
Debaryomyces hansenii	1	0.24
Not detected	256	61.71

Discussion

The detection results of pathogenic microorganisms in the hospital suggest that the detection proportions of *E. coli*, *K. pneumoniae* and *A. baumannii* were large, which is roughly consistent with the monitoring results of drug resistance of bacteria in tertiary hospitals released by CHINET in 2019. The detection rate of *Candida* was high, but the defined daily dose system of antifungal drugs such as voriconazole and micafungin was not high, showing a negative correlation, which might be due to the fact that *Candida* is mostly colonized in organs that communicate with the external environment, such as the gastrointestinal tract, the oral cavity, nasal cavity and pharynx, and the urogenital tract, especially in patients undergoing noninvasive or invasive respiratory ventilation, whose respiratory tract shows a colonization rate of *Candida* as high as 20%. Therefore, although *Candida* is cultivated, patients generally do not need antifungal treatment when they have no symptoms of infection[7-8]. Imipenem and cilastatin and meropenem are more likely to be used in the hospital, which may be related to the broad antibacterial spectrum of carbapenem drugs, covering all kinds of Gram-negative bacilli, Gram-positive cocci, aerobic and anaerobic bacteria, and being highly stable to β-lactamase, and the curative effect is definite. Therefore, they are often the first choice for anti-infection experience treatment of severe patients.

From various indicators, the use of special-use antibiotics in the hospital was reasonable as a whole, but there were still some problems. In specific, for some cases, samples were not sent for detection in time, and the consultation sheets were not filled.

(Continued on page 61)

models, it was found that the model had the best effect, and could achieve fast, non-destructive and high-throughput identification of blueberry production areas.

References

[1] KALT W, CASSIDY A, HOWARD LR, *et al.* Recent research on the health benefits of blueberries and their anthocyanins[J]. Advances in Nutrition, 2020, 11: 224 -236.

[2] SILVA S, COSTA EM, VEIGA M, *et al.* Health promoting properties of blueberries: A review[J]. Critical reviews in food science and nutrition, 2020, 60: 181 -200.

[3] FRANCOIS G, FABRICE V, DIDIER M. Traceability of fruits and vegetables[J]. Phytochemistry, 2020, 173: 112291.

[4] LU SY. Study on the origin of cherries by Raman spectroscopy combined with pattern recognition[D]. Hangzhou: China Jiliang University, 2021. (in Chinese).

[5] KUANG L, NIE J, ZHANG J, *et al.* Discrimination of geographical origin of blueberries from three major producing areas of China using mineral element analyses[J]. Atomic Spectroscopy, 2021, 42: 91 -98.

[6] ZHOU L, ZHANG C, TAHA MF, *et al.* Wheat kernel variety identification based on a large near-infrared spectral dataset and a novel deep learning-based feature selection method[J]. Frontiers in Plant Science, 2020, 11: 575810.

[7] GENG Y, NI H, SHEN H, *et al.* Feasibility of an NIR spectral calibration transfer algorithm based on optimized feature variables to predict tobacco samples in different states[J]. Analytical Methods, 2023, 15: 719 -728.

[8] YUAN L, FU X, YANG X, *et al.* Non-destructive measurement of egg's haugh unit by Vis-NIR with iPLS-Lasso selection[J]. Foods, 2023, 12: 184.

[9] LENG H, CHEN C, CHEN C, *et al.* Raman spectroscopy and FTIR spectroscopy fusion technology combined with deep learning: A novel cancer prediction method[J]. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 2023, 285: 121839.

[10] ZHOU D, YU Y, HU R, *et al.* Discrimination of Tetrastigma hemsleyanum according to geographical origin by near-infrared spectroscopy combined with a deep learning approach[J]. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 2020, 23: 118380.

[11] MISHRA P, BIANCOLILLO A, ROGER JM, *et al.* Rutledge, New data preprocessing trends based on ensemble of multiple preprocessing techniques[J]. TrAC Trends in Analytical Chemistry, 2020, 132: 116045.

[12] LI J, ZHANG H, ZHAN B, *et al.* Nondestructive firmness measurement of the multiple cultivars of pears by Vis-NIR spectroscopy coupled with multivariate calibration analysis and MC-UVE-SPA method[J]. Infrared Physics & Technology, 2020, 104: 103154

[13] GUO HX, LI Y, CHEN LX, *et al.* Source-load extreme scenario identification method based on residual grouping convolutional neural network and multilevel attention mechanism[J]. Power System Technology, 2024, 0688: 1 -17. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU

(Continued from page 56)

Moreover, the microbial detection rate was low, and drugs were used empirically without etiological support sometimes. In view of the above phenomena, clinical pharmacists in the hospital have formulated a series of targeted and operable intervention measures. For example, clinicians are regularly organized to carry out training on the use of special-use antibiotics. With the help of information technology, a prereview system for inpatient medical orders and prescriptions has been loaded, and doctors can pop up a window to prompt the use of precautions, incompatibility, consultation and microbial inspection. Pharmacists can strengthen after-the-fact comments on hospitalized cases, and regularly feed back the comments to various departments. The cooperation among the information department, medical department, central laboratory and other departments is strengthened, and the use catalogue has been formulated to standardize the prescription authority of clinicians and strictly implement the consultation system of special-use antibiotics. Performance rewards and punishments and other measures are implemented to ensure the standardization and rationalization of the use of special-use antibiotics in the hospital and delay the occurrence of drug resistance.

References

[1] HU FP, GUO Y, ZHU DS, *et al.* Surveillance of drug resistance of bacteria in tertiary hospitals by CHINET in 2019[J]. Chinese Journal of Infection and Chemotherapy, 2020, 20(3): 234 -243. (in Chinese).

[2] HONG SN, ZHANG HQ, YAN XB, *et al.* Investigation on the use density of special-use antibiotics in hospitals in recent two years and its relationship with the drug resistance rate of common bacteria[J]. Chinese Journal of Clinical Rational Drug Use, 2024, 17(18): 158 -161. (in Chinese).

[3] LIU CL, CHEN D, XU HY, *et al.* Analysis of resistance of clinically common gram-negative bacilli to three common carbapenems[J]. Medical Laboratory Science and Clinices, 2019, 30(4): 5. (in Chinese).

[4] LU L, YANG TJ, CHEN GF. Analysis of clinical use of special-use antibiotics in a provincial hospital in Zhengzhou[J]. Journal of Henan Medical College, 2024, 36(2): 187 -193. (in Chinese).

[5] YANG S, DUAN QL, MEN X, *et al.* Rationality analysis of the use of special-use antibiotics in 274 inpatients in a hospital[J]. Anti-Infection Pharmacy, 2022, 19(9): 1276 -1279. (in Chinese).

[6] WANG X, HUANG L, YANG L, *et al.* Analysis on the application of special use antibiotics in a hospital from 2019 to 2021[J]. Strait Pharmaceutical Journal, 2024, 36(6): 74 -78. (in Chinese).

[7] HARRIOTT MM, NOVERR MC. Importance of *Candida*-bacterial polymicrobial biofilms in disease[J]. Trends Microbiol, 2011, 19(11): 557 -563.

[8] WANG WQ. Clinical significance of *Candida* detection in lower respiratory tract samples of patients with chronic obstructive pulmonary disease [D]. Shanghai: Shanghai Jiao Tong University, 2020. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU