Infection and Drug Resistance

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ORIGINAL RESEARCH

Evaluation and Analysis of the Rationality of Clinical Use of Carbapenems in Surgical Departments of a Tertiary Hospital in Southwest China

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Purpose: With the increasing frequency and intensity of carbapenem consumption, carbapenem-resistant organisms (CRO) have become a focus of anti-infection research. This study aimed to evaluate the rationality of the clinical use of carbapenems among inpatients in the surgical departments of a tertiary hospital in southwest China.

Patients and methods: A point-score system was established for evaluation based on the clinical practices in surgical departments and selected carbapenem prescriptions from June 2020 to June 2021 for hepatobiliary surgery, gastrointestinal surgery, and neurosurgery in the study hospital. Prescriptions with a total score ≥ 270 were defined as rational. Descriptive statistics were used to describe the characteristics and rationality of the prescriptions. The chi-square test, Mann–Whitney *U*-test, and Kruskal–Wallis *H*-test were used to compare characteristics between rational and irrational prescriptions. Linear regression analysis was used to determine the factors affecting the rationality of carbapenem prescriptions.

Results: According to 192 carbapenem prescription records, the median age of patients was 62 years [IQR, 48.0–73.0], and 20% of patients had abdominal infections, 10% had lung infections, 14% had intracranial infections, and 3% had urinary tract infections. 56% of carbapenem prescriptions were irrational. Compared with rational carbapenem prescriptions, irrational prescriptions had a higher proportion of those with inappropriate indications (49% vs 0%, $p < 0.05$), incorrect variety selection (15% vs 0%, $p<0.05$), and unreasonable assessment of etiology and efficacy (46% vs 8%, $p < 0.05$). Linear regression analysis suggested that the diagnosis of cholecystitis (standardized regression coefficient=0.183, $p<0.05$) and replaced medication (standardized regression coefficient = 0.154, $p<0.05$) influenced the rationality of carbapenem prescriptions.

Conclusion: Our study shows that the irrational use of carbapenems deserves attention, especially in surgical departments. Interventions for carbapenem use that are based on evaluation criteria should be developed to reduce the emergence and spread of carbapenem-resistant bacteria.

Keywords: carbapenem, prescription review, surgery

Introduction

Antimicrobial resistance (AMR) has been listed by the World Health Organization (WHO) as a serious global public health threat. Between 2000 and 2018, the global rate of antibiotic consumption increased by 46%, especially in low- and middle-income countries (LMICs), where it increased by 76%.[1] Antimicrobial resistant infections directly caused 1.27 million deaths in 2019.[2]

Received: 19 January 2023
Accepted: 22 March 2023
Published: 17 April 2023

With the increase in bacterial resistance to second- and third-generation cephalosporins and fluoroquinolones, carbapenems are increasingly used in clinical practice. They play an important role in the antibacterial treatment of multidrug-resistant bacterial infections, mixed aerobic and anaerobic bacterial infections, severe infections, and infections in immunocompromised patients.[3,4]

However, with the increasing use and intensity of carbapenem consumption, carbapenem-resistant organisms (CRO) have become a great concern.[5–7] Owing to the special rectification of the clinical use of antimicrobial drugs in 2011, the intensity of antibiotic use in China decreased from 59.4% in 2011 to 36.8% in 2017, and antibiotic consumption decreased from 85.1 DDDs/100 patient-days to 49.7 DDDs/100 patient-days. However, the intensity of carbapenem consumption increased from 1.83 DDDs/100 person-day to 3.28DDDs/100 person-day in the same period.[8,9] In some areas, the consumption of carbapenem has increased quickly.[10,11] For example, the average annual growth rates of carbapenem use in Guangdong and Jiangsu provinces were 18% and 19%, respectively, from 2019 to 2020.[12]

The use of carbapenems in surgical departments, particularly prolonged use of carbapenems and inappropriate etiological evaluation, is even more concerning. In 2018, the National Health Commission of China issued evaluation criteria for the clinical use of carbapenems, which was mainly used by pharmacists to evaluate the rationality of carbapenem prescriptions afterwards.[13] However, it is difficult for surgeons and other physicians to comply with these evaluation criteria because they are more suitable for the administrative regulation of carbapenem use. Doctors face complex situations when treating patients and may have different perceptions of this evaluation criteria than pharmacists. Based on China's evaluation criteria for carbapenems and other relevant clinical guidelines such as those for abdominal infection and sepsis,[14–16] we established evaluation criteria for carbapenems applicable to surgical departments. The evaluation criteria included five dimensions: indications, variety selection, usage-dosage-compatibility, etiology and efficacy evaluation, prescription management and consultation.

This study aimed to evaluate the rationality of the clinical use of carbapenems among inpatients in the surgical departments of a tertiary hospital in southwest China. This will help inform targeted intervention measures and promote the rational use of carbapenems.

Methods

Study Design and Setting

This retrospective study was conducted in a 3200-bed tertiary teaching hospital in Southwest China. The study included patients who were administered carbapenems (meropenem or imipenem) between June 2020 and June 2021. In addition, prescriptions were drawn from three noteworthy departments, gastrointestinal surgery, hepatobiliary surgery, and neurosurgery, all of which were surgical departments with high carbapenem consumption. We excluded carbapenem prescriptions with durations of less than 72h because these prescriptions might interfere with the assessment of efficacy. A total of 192 prescriptions of carbapenem were included in research samples.

Evaluation Criteria for the Rationality of Carbapenem Prescriptions

We established a point-scoring system for evaluation based on the clinical practices in surgical departments.[13,17] The evaluation criteria were verified by two experts in infectious diseases, three experts in pharmacy and were considered practical in China context.

The evaluation system was based on indications (symptoms that required carbapenem treatment), variety selection of carbapenems, usage-dosage-compatibility, etiology and efficacy evaluation, prescription management and consultation with special-use antibacterial drugs (Table 1). Since it is difficult for surgeons to grasp the indications, the study refined the evaluation criteria for indications with reference to international clinical guidelines, such as the Abdominal Infection and Sepsis Guidelines.[14,15]

A greater impact (100 points) was assigned to indications that could have a major influence. For the evaluation of variety selection, usage-dosage-compatibility, etiology and efficacy, prescription management and consultation were assigned 50 points each. The maximum total score for the five evaluation sections was 300. Prescriptions with a total score of less than 270 were considered unreasonable. High threshold of irrationality of prescription has been implemented because carbapenems are antibiotics in a special-use category in China (Table 1).

Table 1 Evaluation Criteria for the Rationality of Clinical Use of Carbapenems

Evaluation Item	Evaluation Indicators	Scoring Instructions	Points
Indications	Severe infection caused by aerobic gram-negative bacilli that are multi-resistant but sensitive to such drugs.[21]	Yes	90
	Severely ill patients with mixed infection of anaerobic bacteria such as Bacteroides fragilis and aerobic bacteria.[21]	Yes	100
	Empirical treatment of patients with high risk factors for multidrug-resistant gram-negative bacilli infection for whom the pathogen has not been identified and the treatment of enzyme inhibitors or third- or fourth-generation cephalosporins is ineffective (such as agranulocytosis with fever, abdominal surgery, brain surgery with ESBL values, etc.).[21,40]	Yes	80
	Carbapenem-resistant Enterobacteriaceae (CRE) infection requires adequate and combined medication.[16,41]	Yes	90
	*Points will be awarded if any one of the indicators is satisfied.		
Variety selection	Meropenem and panipenem should be used for central nervous system infections. If drug-resistant negative bacteria are considered, meropenem should be used instead of imipenem, biapenem, or ertapenem.[16,42]	Yes	50
	CRE infection and severe infection should use imipenem and meropenem with larger recommended doses.[16]	Yes	50
	Ertapenem should not be used in infections of non-fermentative bacteria such as Pseudomonas aeruginosa and Acinetobacter.[16]	Yes	50
	Pregnant patients are not recommended to use imipenem, panipenem or biapenem.[43]	Yes	50
	Children are not recommended to use biapenem.[13]	Yes	50
	*Points will be awarded if any one of the indicators is satisfied.		
Usage-dosage-compatibility	The usage complies with the recommended usage of carbapenem issued by the National Health Commission of China.[13]	Yes	10
	The dosage complies with the recommended dosage of carbapenem issued by the National Health Commission of China.[13]	Yes	10
	For patients with renal insufficiency, the dosage regimen should be adjusted according to renal function.[13]	Yes	10
	Carbapenem should be avoided in combination with valproic acid.[44,45]	Yes	10
	Imipenem should be avoided in combination with ganciclovir.[46]	Yes	10
	*Points need to be reviewed for each evaluation indicator.		
Etiology and efficacy evaluation	The corresponding etiological examination should be submitted before the use of antibacterial drugs, which refers to bacterial culture.[13]	Yes	20
	There should be laboratory examination to evaluate the curative effect during treatment, such as blood routine, procalcitonin, or re-examination of bacterial culture.[13]	Yes	10
	When the pathogen and drug susceptibility results are clear, the condition should be assessed in time, and de-escalation treatment should be adopted rationally.[16]	Yes	10
	Timely de-escalate when the disease is in remission.[16,21]	Yes	10
	*Points need to be reviewed for each evaluation indicator.		
Prescription management and consultation	The prescription is issued by a doctor with a senior professional title and must be supported by information technology.[13]	Yes	10
	Experts in or out of the hospital are invited for consultation in a timely manner, and have consultation records.[13]	Yes	20
	The use of antibiotics beyond the authority is limited to within 24 hours, and there is a corresponding disease course record.[13]	Yes	10
	Special-use antibiotics file registration management is carried out in accordance with the provisions of the prescribed documents.[13]	Yes	10
	*Points need to be reviewed for each evaluation indicator.		
Total score			300

Data Collection and Analysis

The hospital established a carbapenem prescription management group consisting of a prescription review working group and a prescription review expert group, responsible for extracting medical records and reviewing the results. The prescription data for the three selected departments were collected from the hospital information system. We conducted two prescription reviews: a preliminary review was conducted by two senior clinical pharmacists and a final review was conducted by two experienced infectious disease specialists. Each prescription was assigned a final score after two rounds of review. The hospital's prescription review expert group discussed and confirmed the final score of the prescription if there was a discrepancy between the results of the two prescription reviews. The results of the prescription review were uploaded to the hospital information system and fed back to the relevant departments through the hospital's Office Automated (OA) system.

Descriptive statistics were used to present the characteristics of the carbapenem prescriptions and patients. Continuous variables were expressed as medians and interquartile ranges (IQR), while categorical variables were expressed as counts and proportions. Univariate analysis compared the characteristics of rational and irrational prescriptions using the chi-square test, Mann–Whitney *U*-Test, and Kruskal–Wallis *H*-Test. Multicollinearity test was performed before multivariable analysis. Linear regression analysis was used to determine the factors affecting the rationality of carbapenem prescriptions. The dependent variable for the linear regression was the rationality of the prescription. The independent variables were general characteristics of the prescription. Analyses were performed using SPSS software (version 23.0). $P < 0.05$ were considered statistically significant.

Results

Comparison of Rational and Irrational Carbapenem Prescriptions According to Patient Characteristics

Of the included patients, the median age of patients was 62 years [IQR, 48.0–73.0]; 52% of patients were above 60 years old, 20% had abdominal infections, 10% had lung infections, 14% had intracranial infections, and 3% had urinary tract infections. Of the 192 carbapenem prescriptions, 48%, 32%, and 20% were selected from hepatobiliary surgery, gastrointestinal surgery, and neurosurgery, respectively. Meropenem was used in 59% of the prescriptions (Table 2).

Table 2 Comparison of Rational and Irrational Carbapenem Prescriptions Based on Patient Characteristics

	Total Number of Prescriptions n (%)	Rational Prescriptions n (%)	Irrational Prescriptions n (%)	Statistics/P value
Total (N, %)	192(100)	84(44)	108(56)	
Age (Median, IQR)	62(48–73)	58(48–75)	62(48–72)	Z=−0.195/P=0.845
Age				χ^2=0.333/P=0.564
<60	92(48)	41(48)	51(47)	
>60	100(52)	43(52)	57(53)	
Diagnosis				χ^2=88.177/P<0.05
Abdominal infection	38(20)	17(20)	21(19)	
Lung infection	20(10)	9(11)	11(10)	
Intracranial infection	27(14)	15(18)	12(11)	
Urinary tract infection	5(3)	3(4)	2(2)	
Severe ill comorbid cancer	18(9)	6(7)	12(11)	
Cholangitis	22(11)	6(7)	16(15)	
Cholecystitis	6(3)	5(6)	1(1)	
Peritonitis	20(10)	9(11)	11(10)	
Pancreatitis	7(4)	2(2)	5(5)	

(*Continued*)

Table 2 (Continued).

	Total Number of Prescriptions n (%)	Rational Prescriptions n (%)	Irrational Prescriptions n (%)	Statistics/P value
Obstructive jaundice	9(5)	3(4)	6(6)	
Sepsis	3(2)	2(2)	1(1)	
Prophylaxis of postoperative infection	11(6)	2(2)	9(8)	
Septic shock	6(3)	5(6)	1(1)	
Department				χ^2=23.844/P<0.05
Hepatobiliary Surgery	93(48)	34(40)	59(55)	
Gastrointestinal Surgery	61(32)	29(35)	32(30)	
Neurosurgery	38(20)	21(25)	17(15)	
Medications				χ^2=84.875/P<0.05
Meropenem	114(59)	47(56)	67(62)	
Imipenem	68(36)	31(37)	37(34)	
Replaced Medication (Meropenem/Imipenem)	10(5)	6(7)	4(4)	

56% of the prescriptions were irrational, with scores below 270. Compared with rational carbapenem prescriptions, irrational prescriptions were greater in hepatobiliary surgery department (55% vs 40%, $p < 0.05$) and were more often co-prescribed with meropenem (62% vs 56%, $p < 0.05$). No significant difference was found between the rational and irrational prescriptions based on patients' age ($p > 0.05$) (Table 2).

Comparison of Rational and Irrational Carbapenem Prescriptions, by Evaluation Criteria

Based on the evaluation criteria, 72% of the prescriptions were medications with indications, and 92% and 96% of the prescriptions had correct variety selection and appropriate usage-dosage-compatibility, respectively. Only 63% and 53% of the prescriptions had reasonable etiology and efficacy evaluations and proper prescription management and consultation, respectively. Compared with rational carbapenem prescriptions, irrational prescriptions had a higher proportion of those with inappropriate indications (49% vs 0%, $p < 0.05$), incorrect variety selection (15% vs 0%, $p<0.05$), and unreasonable assessment of etiology and efficacy (46% vs 8%, $p < 0.05$). No significant differences were found between rational and irrational prescriptions in terms of prescription management and consultation ($p > 0.05$) (Table 3).

Table 3 Comparison of Rational and Irrational Carbapenem Prescriptions, by Evaluation Criteria

	Total Number of Prescriptions n (%)	Rational Prescriptions n (%)	Irrational Prescriptions n (%)	Statistics/P value
Indication				χ^2=38.521/P<0.05
Yes	139(72)	84(100)	55(51)	
No	53(28)	0(0)	53(49)	
Selection of variety				χ^2=133.333/P<0.05
Yes	176(92)	84(100)	92(85)	
No	16(8)	0(0)	16(15)	
Meropenem or panipenem were not selected for central nervous system infections	16(8)	0(0)	16(15)	

(*Continued*)

Table 3 (Continued).

	Total Number of Prescriptions n (%)	Rational Prescriptions n (%)	Irrational Prescriptions n (%)	Statistics/P value
Usage-dosage-compatibility				χ^2=161.333/P<0.05
Yes	184(96)	81(96)	103(95)	
No	8(4)	3(4)	5(5)	
Insufficient dose of medication	3(2)	1(1)	2(2)	
Exceeded dose of medication	1(1)	0(0)	1(1)	
No adjustment to the dosing regimen for patients with renal insufficiency	4(2)	2(3)	2(2)	
Assessment of etiology and efficacy				χ^2=13.021/P<0.05
Yes	121(63)	77(92)	58(54)	
No	71(37)	7(8)	50(46)	
No etiological examination before medication	11(6)	0(0)	11(10)	
No laboratory examinations for efficacy evaluation	13(6)	1(1)	12(11)	
No de-escalation therapy	36(19)	6(7)	30(28)	
No etiological examination before medication and No de-escalation therapy	6(3)	0(0)	6(6)	
No laboratory examinations for efficacy evaluation and No de-escalation therapy	4(2)	0(0)	4(4)	
No etiological examination before medication, No laboratory examinations for efficacy evaluation and No de-escalation therapy	1(1)	0(0)	1(1)	
Prescription management and consultation of special-use antibiotics				χ^2=0.521/P=0.470
Yes	101(53)	73(87)	28(26)	
No	91(47)	11(13)	80(74)	
No consultation	67(35)	11(13)	56(52)	
No medication records	1(1)	0(0)	1(1)	
No consultation and No medication records	23(11)	0(0)	23(21)	

Factors Influencing the Rationality of Carbapenem Prescriptions

Univariate analysis showed that the median scores of the rational prescriptions of hepatobiliary surgery (280 [270–290] vs 240 [180–270], $p < 0.05$), gastrointestinal (270 [270–270] vs 260 [253–268], $p < 0.05$) and neurosurgery (270 [260-273] vs. 260 [198-270], $p < 0.05$) were higher than the median score of unreasonable prescriptions (Table 4).

Further linear regression analysis showed that the diagnosis of cholecystitis was significantly associated with the rationality of carbapenem prescriptions. Compared with that of irrational prescriptions, the median (IQR) score for prescriptions with the diagnosis of cholecystitis was significantly higher for rational prescriptions (standardized regression coefficient=0.183, 270 [270–280] vs 260 [260–260], $p < 0.05$). In addition, replaced medication (standardized regression coefficient = 0.154, $p < 0.05$) was significantly associated with the rationality of prescriptions (Table 4).

Discussion

This study focused on the irrational use of carbapenems in surgical departments. Based on the evaluation criteria for carbapenem use in surgical departments established in this study, we found that irrational carbapenem prescriptions in this hospital accounted for 56% of the total sampled prescriptions, which was higher than that in other hospitals.[18–20] Although carbapenems remain the cornerstone of the treatment of serious infections, we must pay attention to their irrational use, especially in surgical departments, to alleviate the situation of gram-negative bacteria resistant due to carbapenem abuse.[21]

Table 4 Analysis of Factors Influencing the Rationality of Carbapenem Prescriptions

	Median (IQR) Score	Univariate Analysis			Multicollinearity Test		Multivariable Analysis		
		Median (IQR) Score for Rational Prescriptions	Median (IQR) Score for Irrational Prescriptions	Statistics/ P value	Tolerance	VIF	Standardized Regression Coefficients	P value	95% CI
Age				χ^2=7.391/P=0.831					
<60 (N=92)	260(200–270)	270(260–280)	260(190–270)		/	/	/	/	/
>60 (N=100)	260(190–270)	270(260–280)	260(200–270)		0.859	1.177	−0.035	P=0.633	−15.019 to 9.153
Diagnosis				χ^2=163.071/P=0.133					
Abdominal infection	260(200–270)	270(260–273)	260(190–270)		/	/	/	/	/
Lung infection	260(200–270)	270(260–280)	260(190–270)		0.450	2.221	0.071	P=0.492	−18.153 to 37.595
Intracranial infection	270(260–270)	270(250–270)	270(270–280)		0.876	1.141	0.052	P=0.487	−24.781 to 51.859
Urinary tract infection	270(260–270)	270(270–270)	260(253–260)		0.180	5.545	0.216	P=0.188	−12.812 to 64.587
Severe ill comorbid cancer	260(198–270)	270(260–270)	260(190–270)		0.744	1.344	0.100	P=0.216	−37.024 to 8.420
Cholangitis	260(190–270)	280(270–290)	250(190–270)		0.583	1.717	−0.031	P=0.737	−27.507 to 19.496
Cholecystitis	270(270–280)	270(270–280)	260(260–260)		0.826	1.210	0.183	P<0.05	7.713 to 79.955
Peritonitis	260(200–270)	270(270–280)	260(198–270)		0.638	1.567	−0.083	P=0.339	−34.776 to 12.048
Pancreatitis	240(180–260)	270(270–270)	190(170–240)		0.795	1.258	−0.045	P=0.564	−44.218 to 24.172
Obstructive jaundice	250(183–270)	270(270–280)	190(170–240)		0.762	1.313	0.015	P=0.849	−27.980 to 33.954
Sepsis	260(250–270)	260(250–270)	190(190–190)		0.935	1.070	0.017	P=0.818	−42.085 to 53.216
Prophylaxis of postoperative infection	260(190–270)	270(270–270)	260(190–270)		0.741	1.350	−0.108	P=0.183	−47.920 to 9.215
Septic shock	270(260–270)	270(260–270)	260(260–260)		0.821	1.217	0.142	P=0.065	−2.205 to 70.256
Department				χ^2=54.470/P0.05					
Hepatobiliary Surgery	250(190–270)	280(270–290)	240(180–270)		/	/	/	/	/
Gastrointestinal Surgery	260(200–270)	270(270–270)	260(253–268)		0.314	3.180	0.091	P=0.463	−13.734 to 30.032
Neurosurgery	270(260–270)	270(260–273)	260(198–270)		0.167	5.982	0.021	P=0.903	−32.895 to 37.247
Medication				χ^2=25.630/P=0.372					
Meropenem	260(190–270)	270(260–270)	260(190–270)		/	/	/	/	/
Imipenem	260(192–277)	270(260–280)	260(200–270)		0.412	2.424	0.085	P=0.430	−11.152 to 26.048
Replaced Medication (Meropenem/Imipenem)	270(260–272)	270(260–270)	270(260–280)		0.811	1.233	0.154	P<0.05	0.462 to 57.577
Evaluation item									
Indications	70(0–70)	70(70–80)	70(0–70)	χ^2=192.000/P<0.01	/	/	/	/	/
Variety selection	50(50–50)	50(50–50)	50(50–50)	χ^2=78.523/P<0.01	/	/	/	/	/
Usage-dosage-compatibility	50(50–50)	50(50–50)	50(50–50)	χ^2=26.942/P<0.05	/	/	/	/	/
Etiology and efficacy evaluation	40(40–50)	50(50–50)	50(40–50)	χ^2=100.732/P<0.01	/	/	/	/	/
Prescription management and consultation	40(40–50)	50(40–50)	50(40–50)	χ^2=104.504/P<0.01	/	/	/	/	/

https://doi.org/10.2147/IDR.S403787

Similar to a study by Wagner et al,[22] we found a higher proportion of irrational prescriptions for hepatobiliary surgery (55%), gastrointestinal surgery (30%), and neurosurgery (15%). This may be because most of patients in these surgical departments had infection symptoms, such as abdominal infection, intracranial infection, or lung infection; and were older; with underlying diseases. Based on established criteria, we identified the reasons for irrational carbapenem prescription in surgical departments. The selection of carbapenem varieties and usage-dosage-compatibility of carbapenems were relatively reasonable, with rational rates as high as 92% and 96%, respectively. The irrational use of carbapenems was mainly due to medication without indications, improper evaluation of the etiology and efficacy, and imperfect prescription management and consultation. For example, irrational prescriptions had a higher proportion of those with inappropriate indications than rational prescriptions (49% vs 0%, $p < 0.05$). The univariate analysis had also indicated that indications were related to the rationality of prescriptions. The prescription review revealed that the use of carbapenems in patients without serious infections (53, 28%) was the main manifestation of medications without indications. This indicates that surgeons tend to adopt conservative treatment options because of the fear of negative patient outcomes. Therefore, antibiotic prescriptions are often considered necessary by surgeons, even without a clear indication, conservative intervention to reduce the possible risk of infection.[23] For instance, the non-discontinuation of antibiotics after surgery is a common problem for surgeons.[17] But the use of special-use antibiotics such as carbapenems to avoid postoperative infections is mostly unreasonable. The view of Charani et al also confirms that surgeon's fear of negative outcomes for patient outweighs their fear of adverse consequences from inappropriate use of antibiotics.[24]

This study found that the improper evaluation of etiology and efficacy also accounted for the irrational use of carbapenem because a higher proportion of prescriptions with improper efficacy and etiology evaluations were found in irrational prescriptions (46% vs 8%, $p < 0.05$). The inappropriate evaluation of etiology and efficacy was mainly due to a lack of etiological or laboratory examination before the use of carbapenem. Nearly a quarter (17.1%) of the carbapenems in this study were prescribed without prior etiological or laboratory examinations, a higher percentage compared to studies in a large UK teaching hospital (5%).[25] A study by Bahrampour et al also showed that doctors tend to underestimate etiological examination and the empirical use of carbapenems is common as they believe that the use of extend-ed-spectrum antibiotics would have a rapid and good effect.[26,27] Similarly, the proportion of irrational prescription with inappropriate prescription management and consultation was higher than that of reasonable prescriptions (74% vs 13%, $p = 0.47$). In our study, 41.1% of the carbapenems were prescribed without prior consultation. Surgeons' knowledge of the rational use of carbapenems may be limited, whereas the lack of multi-disciplinary consultation before prescribing prevents infectious disease doctors, pharmacists and other professionals from judging the rationality of prescriptions, thereby increasing the possibility of unreasonable prescriptions.[28] The univariate analysis also indicated the association between evaluation of etiology and efficacy, prescription management and consultation and the rationality of prescription.

Multivariable analysis showed that prescriptions with cholecystitis diagnosis were more reasonable. Existing literatures have showed that carbapenem is usually the priority choice for treatment of cholecystitis.[29,30] While we identified the significant association between the replaced medication and the rationality of prescriptions, further research is needed to explore the reason behind this pattern.

Our study results should be interpreted in the context of Chinese health systems.

The large number of patients in surgical departments in China and the unbalanced allocation of medical resources lead to a heavier workload for surgeons, which may be one of the reasons why they cannot strictly follow the regulations of carbapenems use. A study by Massimo et al also found that an unbalanced doctor-patient ratio overwhelms surgeons, thereby reducing their compliance with guidelines and regulations.[31] This phenomenon is more common in tertiary hospitals in China, owing to the imperfect tiered medical system.

Additionally, the doctor-patient relationship is in tension, which has a negative impact on doctors' medication judgment. Poor communication between doctors and patients lead to a high frequency of doctor-patient conflicts in China.[32] As a result, many surgeons are more audacious in prescribing antibiotics, particularly the special-use antibiotics such as carbapenems to achieve more "effective" treatment including addressing secondary infections after surgery. In particular, doctors are often under pressure when treating patients with severe infections. Consequently, they often prescribe carbapenems without a rigorous evaluation of the patient's condition.

A few policy implications can be drawn from our study to promote the rational use of special-use antibiotics such as carbapenems. First, hospitals should establish evaluation criteria for the rationality of carbapenem use, tailored to each department.[22] The evaluation criteria designed in this study are helpful for identifying the reasons for irrational prescriptions and can effectively guide doctors to use carbapenems rationally. In the clinical use of carbapenems, antibiotic selection and efficacy evaluation should be considered according to the corresponding patient indications to reduce inappropriate empirical medication. The role of pathogenic examinations also cannot be ignored. Therefore, we suggest that the laboratory examination rate should be used as an indicator for rationality evaluation of carbapenem prescriptions.[33]

Second, the multi-department cooperation system should be improved, to support the analysis of the rationality of carbapenem use. The hospital needs to promote a multi-disciplinary team (MDT) mechanism to improve the communication and cooperation efficiency of the MDT team during consultations.

Meanwhile, Antimicrobial Stewardship Program (ASP) interventions are still worthy of attention, because the effect of ASP in reducing the irrational use of carbapenems is evident.[34–38] Hospital administrators should be aware of the importance of multidisciplinary collaboration in ASP, particularly involving surgeons. Studies have demonstrated that surgeons are less receptive to ASP interventions than other doctors. However, an ASP team involving surgeons can make ASP recommendations more acceptable, thereby promoting the rational use of carbapenems among surgeons.[17]

Finally, strengthening doctors' education is important.[35,37,39] Hospitals can regularly organize trainings or seminars, and case studies on carbapenem prescription evaluations can be conducted. Simultaneously, hospitals can increase the dissemination of carbapenem guidelines through convenient tools such as brochures, which will help increase doctors' compliance with the guidelines.

The main limitations of this study are that it was a single-center study, limited to some surgical departments of a tertiary hospital in Southwest China, and the sample size was small. Additionally, the evaluation criteria established in this study did not consider other surgical factors, which may not reflect the complexity of clinical practice. Despite these limitations, we believe that our study is noteworthy because we established a criteria for evaluating the rationality of the clinical use of carbapenems in the surgical department, thus supporting the rational use of carbapenem.

Conclusion

Our study shows that the irrational use of carbapenems deserves more attention, especially in surgical departments. Therefore, interventions for carbapenem use should be developed to reduce the emergence and spread of carbapenem-resistant bacteria. The evaluation criteria for the rationality of the clinical use of carbapenems established in this study may be useful in such interventions.

Statement of Ethics

This study followed the guidelines for human studies and complied with the Declaration of Helsinki. Informed consent was obtained from the study participants prior to study commencement. This work obtained ethical approval from the Ethics Committee of the First Affiliated Hospital of Guangzhou Medical University, China (2019-53).

Acknowledgments

The authors thank all participants who participated in this study. The author expresses his gratitude to the First Affiliated Hospital of Chongqing Medical University and State Key Laboratory of Respiratory Disease for their support. We thank Wang Jiong for her work during the concept interpretation.

Funding

This research was funded by the National Natural Science Foundation of China (Grant Number 81861138056), the National Social Science Foundation of China (Grant Number 20&ZD122), the Investigator-Initiated Trial Fund of The First Affiliated Hospital of Guangzhou Medical University (Grant Number DSPC-MPM002).

Disclosure

The authors declare no conflict of interest.

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