The Pattern of Antibiotic Utilization in Intensive Care Units of a Tertiary Care Public Hospital

Deepak Kumar Verma[1], Anusuya Gehlot[2], Rajkumar Rathore[2], Neeta Kumari[3*]

[1]Department of Pharmacology, S.M.M.H Government Medical College, Saharanpur, Uttar Pradesh, India.

[2]Department of Pharmacology, Dr. SN Medical College, Jodhpur, Rajasthan, India.

[3]Department of Physiology, S.M.M.H Government Medical College, Saharanpur, Uttar Pradesh, India.

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Abstract

Background: Resistance to antibiotics is increasing. Hospital overuse of antibiotics is a significant contributor to antibiotic resistance. A rational use of antibiotics is necessary to optimize the outcome of critically ill patients. The study aimed to examine the utilization pattern of antibiotics in the intensive care units (ICUs) of a tertiary care public hospital.

Methods: This observational study was conducted over eight months in the medical ICU (MICU), surgical ICU (SICU), and trauma ICU (TICU). Data regarding prescribed antibiotics, including name, content, dose, route of administration, and duration of treatment, were used to describe the pattern and estimate the consumption. The defined daily dose (DDD)/100 bed-days of each prescribed antibiotic was calculated.

Results: The three most frequently used antibiotics in all the ICUs were piperacillin + tazobactam (107 patients), Meropenem (74 patients), and Metronidazole (72 patients). The total utilization of antibiotics was 46.94, 53.91, and 38.84 DDD/100 bed-days in the TICU, SICU, and MICU wards, respectively. Antibiotics with the highest utilization (DDD/100 bed-days) in each ward were meropenem (13.47) in the SICU, piperacillin + tazobactam (10.64) in the TICU, and ceftriaxone (9.49) in the MICU.

Conclusion: The present study results indicated that the percentage share of different antibiotic drugs varied according to the type of ICU and disease. Penicillin combinations, cephalosporin, and carbapenems were the most commonly used antibiotic groups in all ICUs. High consumption of broad-spectrum antibiotics underscores the importance of stewardship programs to overcome the growing resistance to available effective antibiotics in ICUs.

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Keywords: Antibiotics; Tertiary Care Hospital; Intensive Care Units; Consumption

Introduction

Optimal antibiotic use is essential in the critical care context, particularly in light of the absence of novel antimicrobial agents and the growing resistance to available antibiotics (1). Antibiotic consumption and the emergence and spread of resistant strains in hospitals and intensive care units (ICUs) have been directly linked in epidemiological studies.

Overuse and misuse of antibiotics are certainly contributing to the increasing problems caused by antibiotic-resistant bacteria (2,3). Rational use of antibiotics is necessary to optimize patients' outcomes (4). Critically ill patients admitted to ICUs are at greater risk of serious morbidity and death if antibiotic therapy fails (5). Resistance also results in longer hospital stays for patients, increased costs, and death (6).

It has been recommended to optimize antibiotic use in ICUs by timely initiation of empiric antibiotics, considering the susceptibility pattern in the setting,

*** Corresponding Author:** Neeta Kumari
Address: Department of Physiology, S.M.M.H Government Medical College, Saharanpur, Uttar Pradesh, India. Tel: +91 7976401855.
Email: neeta771@gmail.com

frequent evaluations, and de-escalating the treatment as soon as possible, and considering appropriate critical care-specific dosing strategies (4).

Antibiotic use in ICUs in India has been shown to be high in some previous studies. The inappropriate use in previous studies and reports in this country is characterized by the overuse of broad-spectrum and last-resort antibiotics. Inconsistent stewardship programs and high rates of infections in ICUs might be the main drivers of the observed consumption pattern (7,8). The aim of the study was to examine the consumption pattern of antibiotics in the ICUs of a tertiary care public hospital.

Methods

This observational study was conducted in the trauma ICU (TICU), medical ICU (MICU), and surgical ICU (SICU) wards of the Mathura Das Mathur (MDM) Hospital, Jodhpur, Rajasthan. This tertiary care public hospital is the largest referral hospital in Jodhpur, the second important city of Rajasthan (a large state in the northwest of India). The data from the patients admitted to the ICUs from August 2022 to March 2023 who were prescribed an antibiotic were registered.

The study was approved by the Institutional Research Ethics Committee (SNMC/IEC/2022/536). The researcher signed a commitment agreement regarding data utilization for study purposes, ensuring ethical compliance in accordance with regulations.

A total of 100 prescriptions were collected from each ICU (i.e., TICU, MICU, and SICU) to fulfill the least recommended number of cases in medication utilization studies (9). The patients of all ages of either sex admitted to the TICU, MICU, and SICU wards during the study period, who had been prescribed antibiotics and were willing to participate, were included in the study.

The data were collected during regular ICU rounds in the TICU, MICU, and SICU wards. Senior consultants were involved in the prescription in different ICUs. A standard data entry format was designed and used to enter all the necessary clinical and medication data. Data regarding prescribed antibiotics, including name, content, dose, route of administration and duration of treatment were used to describe the pattern and estimate the consumption. The WHO ATC/DDD system was considered (10). Defined daily dose (DDD) was used as the standard unit of measurement to calculate the consumption metric of DDD/100 bed-days (10). The DDD/100 bed-days of each prescribed antibiotic was calculated considering the reported bed-days for each of the study wards.

All data were entered into a master chart using a Microsoft Excel sheet and subjected to statistical analysis. Data were expressed as percentages and as Mean ± standard deviation (SD).

Results

Totally 300 patients were studied. Demographic and clinical characteristics of the patients are described in Table 1. Mortality rate and mortality rate after 07 days were higher in the medical ICU (63%) as compared to the surgical (10%) and trauma (25%) ICUs. While, mortality rate before 07 days was higher in surgical (21%) and trauma (21%) ICUs than medical (6%) ICU. The average duration of antimicrobial use seems to be more in the surgical and trauma ICUs as compared to the medical ICU.

Table 1. Demographic and clinical characteristics of patients in the three ICUs

	MICU (N= 100)	TICU (N=100)	SICU (N=100)
Age (years), Mean±SD	46.27±9.16	49.17±8.06	49.17±8.06
Total Mortality, %	69	31	31
Mortality before 07 days, %	6	21	21
Mortality after 07 days, %	63	10	10
Transfer to ward, %	31	69	69
ICU stay (days), Mean ± SEM	4.52±3.02	7.18±8.05	7.18±8.05
Number of drugs prescribed, Mean±SD	9.71± 2.23	6.2±1.37	6.2±1.37
Duration of antibiotic therapy (days), Mean±SD	4.90±2.23	6.97±2.45	6.97±2.45

ICU: Intensive Care Unit, N: Number, MICU: Medical Intensive Care Unit, SD: Standard Deviation, SEM: Standard Error of Mean, SICU: Surgical Intensive Care Unit, TICU: Trauma Intensive Care Unit

In terms of reasons for ICU admission, 19% of the patients in the MICU were affected by respiratory failure or chronic obstructive pulmonary disease (COPD), followed by 17% with coronary artery disease. On the other hand, 51% of the subjects in the SICU ward were admitted with contusions in the brain/intracerebral hemorrhage/subdural hematoma/brain tumor/lesion, followed by 12% with spinal cord injury. Moreover, 79% of the patients in the TICU were affected with contusions in the brain/ intracerebral hemorrhage/subdural hematoma, followed by 5% with pneumothorax.

Table 2 summarizes the frequency of each antibiotic used for study patients in each ICU. The most commonly used antibiotic group in MICU, SICU, and TICU was nitroimidazole (21.42%), cephalosporin (25.11%), and penicillin Combination (27.41%), respectively. The three most frequently used antibiotics in all the ICUs were piperacillin + tazobactam (107 patients), Meropenem (74 patients), and Metronidazole (72 patients).

Metronidazole (21.43%) and ceftriaxone (12.50%) were the two most commonly used antibiotics in MICU. Meropenem (18.29%), piperacillin + tazobactam (9.78%), and levofloxacin (9.78%) were the top three antibiotics used in SICU. The three most frequently used antibiotics in TICU were piperacillin + tazobactam (24.32%), amikacin (10.81%), and cefoperazone + sulbactam (10.03%). The administration route of all antibiotics was intravenous except for cotrimoxazole, which was oral.

Table 2. The frequency of each antibiotic used for study patients in each ICU

Antibiotic Group	Antibiotics	MICU N (%)	SICU N (%)	TICU N (%)
Cephalosporin		**41 (18.30)**	**59 (25.11)**	**46 (17.76)**
	Cefixime	1 (0.45)	2 (0.85)	0 (0)
	Ceftazidime	0 (0)	12 (5.11)	3 (1.15
	Cefotaxime	2 (0.89)	5 (2.13)	5 (1.93)
	Ceftriaxone	28 (12.50)	15 (6.38)	8 (3.08)
	Cefepime + Tazobactam	2 (0.89)	8 (3.40)	4 (1.54)
	Cefoperazone + Sulbactam	8 (3.57)	17 (7.23)	26 (10.03)
Penicillin Combination		**36 (16.07)**	**33 (14.04)**	**71 (27.41)**
	Amoxicillin + Clavulanic Acid	3 (1.34)	7 (2.99)	4 (1.54)
	Piperacillin + Tazobactam	21 (9.37)	23 (9.78)	63 (24.32)
	Ticarcillin+ Clavulanic Acid	12 (5.36)	3 (1.28)	4 (1.54)
Carbapenems		**28 (12.5)**	**49 (20.85)**	**22(8.49)**
	Meropenem	21 (9.37)	43 (18.29)	10(3.86)
	Imipenem + Cilastatin	7 (3.12)	6 (2.55)	12(4.63)
Monobactam		**0 (0)**	**0 (0)**	**5 (1.93)**
	Aztreonam	0 (0)	0 (0)	5(1.93)
Sulfonamides		**0 (0)**	**1 (0.42)**	**3(1.15)**
	Cotrimoxazole	0 (0)	1 (0.42)	3 (1.15)
Macrolide		9 (4.02)	2 (0.85)	0 (0)
	Azithromycin	9 (4.02)	2 (0.85)	0 (0)
Fluroquinolone		**26 (11.61)**	**23 (9.78)**	**15(5.79)**
	Levofloxacin	21 (9.37)	23 (9.78)	10(3.86)
	Ciprofloxacin	5 (2.23)	0 (0)	5(1.93)
Aminoglycoside and Lincosamide		**15 (6.70)**	**18 (7.65)**	**28(10.81)**
	Amikacin	8 (3.57)	15 (6.38)	28(10.81)
	Clindamycin	7 (3.12)	3 (1.27)	0 (0)
Nitroimidazole		**48 (21.43)**	**11 (4.68)**	**13(5.01)**
	Metronidazole	48 (21.43)	11 (4.68)	13 (5.01)
Others		**18 (8.03)**	**39 (16.59)**	**56 (21.62)**
	Vancomycin	6 (2.68)	15 (6.38)	24 (9.26)
	Teicoplanin	6 (2.68)	4 (1.70)	4 (1.54)
	Rifampicin	3 (1.34)	0 (0)	0 (0)
	Linezolid	2 (0.89)	5 (2.12)	17 (6.56)
	Polymyxin B	1 (0.45)	15 (6.38)	11 (4.24)

The utilization of antibiotics in DDD/100 bed-days is described in Table 3. The total utilization of antibiotics in the ICUs was 139.69 DDD/100 bed-days; it was 46.94, 53.91, and 38.84 DDD/100 bed-days in the TICU, SICU, and MICU wards, respectively.

Table 3. Utilization of antibiotics (DDD/100 bed-days), in the three ICUs

Antibiotics	Trauma Intensive Care Unit (N=100)			Surgical Intensive Care Unit (N=100)			Medical Intensive Care Unit (N=100)		
	Patients (N)	Utilization in DDD	DDD/100 bed days	Patients (N)	Utilization in DDD	DDD/100 bed days	Patients (N)	Utilization in DDD	DDD/100 bed days
Cefuroxime	0	0	0	2	90	0.43	1	45	0.21
Ceftazidime	3	9	0.32	12	18.5	0.67	0	0	0
Cefotaxime	5	16	0.57	5	10	0.36	2	4	0.14
Ceftriaxone	8	58	2.10	15	162	5.86	28	262	9.49
Cefepime + Tazobactam	4	13.5	0.48	8	39.37	1.42	2	10.12	0.36
Cefoperazone + Sulbactam	26	144	5.21	17	74.25	2.69	8	21	0.76
Amoxicillin + Clavulanic Acid	4	20	0.72	7	26.4	0.95	3	32.8	1.88
Piperacillin + Tazobactam	63	238.6	10.64	23	86.8	3.14	21	80	2.89
Ticarcillin + Clavulanic Acid	4	7.02	0.25	3	7.9	0.17	12	18.13	0.65
Meropenem	10	68	2.42	43	372	13.47	21	84	3.04
Imipenem + Cilastatin	12	47.75	1.76	6	37.5	1.35	7	30	1.08
Aztreonam	5	31.5	1.14	0	0	0	0	0	0
Cotrimoxazole	3	4.8	0.17	1	1.68	0.06	0	0	0
Azithromycin	0	0	0	2	33.3	1.20	9	65	2.35
Levofloxacin	10	29	1.05	23	148	5.36	21	106	3.84
Ciprofloxacin	5	6.75	0.24	0	0	0	5	4.75	0.17
Amikacin	28	207	7.5	15	86	3.11	8	49	1.77
Clindamycin	0	0	0	3	15.3	0.55	7	30	1.86
Metronidazole	13	36	1.30	11	30.6	1.11	48	166	6.01
Vancomycin	24	89	3.22	15	100	3.62	6	13	0.47
Teicoplanin	4	45	1.63	4	21	0.76	6	32	1.15
Rifampicin	0	0	0	0	0	0	3	10	0.36
Linezolid	17	54.6	3.29	5	21.6	1.30	2	3	0.18
Polymyxin B	11	80.8	2.93	15	174.86	6.33	1	4.76	0.17

DDD: Defined Daily Doses, N: Number

Considering DDD/100 bed-days, the top three antibiotic groups consumed in the MICU were cephalosporins (10.96), nitroimidazole (6.01), and penicillin combinations (5.42). The most highly consumed (DDD/100 bed-days) antibiotic groups in SICU were carbapenems (14.8), other antibiotics (12.01), and cephalosporins (11.43). In the TICU, penicillin combinations, other antibiotics, and cephalosporins had the highest consumption with the DDD/100 bed-days of 11.61, 11.01, and 8.68, respectively.

Antibiotics with the highest utilization (DDD/100 bed-days) in each ward were meropenem (13.47) in the

SICU, piperacillin+tazobactam (10.64) in the TICU, and ceftriaxone (9.49) in the MICU. Antibiotics of the penicillin combination group had higher utilization (DDD/100 bed-days) in TICU (11.61) than in the SICU (4.26) and MICU (5.42) wards.

The utilization (DDD/100 bed-days) of carbapenem in SICU was 14.8, which was more than three times that had been used in each of the other wards. Meropenem was used in the SICU in an amount of 13.47 DDD/100 bed-days, accounting for the highest consumption among all antibiotics used in three wards.

Consumption (DDD/100 bed-days) of metronidazole and ceftriaxone was higher in the MICU (6.01 and 9.49) in comparison to the SICU (1.1and 5.86) and TICU (1.30 and 2.10) wards. However, amikacin was used in higher amounts in the TICU (7.58) in comparison to the SICU (3.11) and MICU (1.77). Levofloxacin consumption was also higher in the SICU and MICU (5.36 and 3.84) compared to TICU (1.29).

Discussion

In the present study, some signals of irrational antibiotic use were detected in the ICUs. Moreover, previous studies showed a significant positive association between the total number of prescribed antibiotics and mortality (11). We found that the total mortality rate and mortality rate after seven days of ICU stay were higher in the MICU compared to the SICU and TICU. On the other hand, the mortality rate before seven days was higher in the SICU and TICU compared to the MICU. Overall ICU mortality rate in our study was at least 4-fold the rate observed in the Intensive Care Over Nations (ICON) audit (12). Another study conducted in much lower resource settings in India found that the mortality rate was also high (13).

Several studies have consistently indicated that the mortality rate is higher in MICUs than SICUs and TICUs. This is often attributed to the types of patients admitted to MICUs, who may have more complex and severe medical conditions requiring longer and more intensive support (14). These results may be influenced by variables such as the degree of disease at admission, the accessibility and efficacy of treatments, and the overall quality of care.

Utilization (DDD/100 bed-days) of antibiotics was higher in the SICU and TICU than in the MICU. The average duration of antibiotic use was also longer in the SICU and TICU compared to the MICU. A longer hospital stay, which is typical in surgical patients, and the increased susceptibility of surgical and trauma patients to infections could explain our observed difference (15-17). In this study, we found that a substantial number of patients used more than one antibiotic concurrently. Also, a study done by Biswal et al. reported that the mean number of drugs prescribed was 12.6 (18). Irrational use of antibiotics has been reported to be a contributing factor to poor outcomes such as prolonged length of stay and death in the ICU (19).

The most frequently used antibiotic group was nitroimidazole (21.42%), followed by cephalosporin (18.30%) in the MICU. Considering the consumption amount, ceftriaxone, metronidazole, and levofloxacin had the highest DDD/100 bed-days in MICU. Medical ICUs often treat patients with a wide range of medical conditions, including sepsis, pneumonia, and other systemic infections. The complexity and potential involvement of multiple pathogens in these infections can lead to the use of broad-spectrum antibiotics or combinations of drugs to target a wider range of potential organisms (20).

The three most frequently used antibiotics in all the ICUs were piperacillin + tazobactam, meropenem, and metronidazole. Cephalosporins and other broad-spectrum antibiotics are also commonly used in ICUs in other countries (21). Similarly, a study also found that ceftriaxone was the most commonly used antibiotic in ICUs (22). This was because these antibiotics are frequently used in ICUs to treat various infections, including hospital-acquired pneumonia (HAP), intra-abdominal infections, sepsis, and infections in febrile neutropenic patients.

The DDD/100 bed-days of cephalosporins and nitroimidazole were higher in the MICU compared to SICU and TICU in the present study. According to one study, the MICU had a substantially greater DDD/100 bed-days of cephalosporins than the surgical and neurosurgical ICUs (23). On the other hand, meropenem, ceftriaxone, levofloxacin, and piperacillin + tazobactam, were among the top antibiotics used in SICU. Meropenem had the highest DDD/100 bed-days in this ward. This is likely due to the higher incidence of surgical infections, which are often treated with broad-spectrum antibiotics (23). SICU had the largest DDD/100 bed-days in our study.

Piperacillin + tazobactam, amikacin, and cefoperazone + sulbactam were the most used antibiotics in TICU. This is likely due to the higher risk of infections, particularly in trauma patients who are more likely to have open wounds or invasive procedures. However, in the Santosh et al. study, DDD/100 bed-days of ampicillin+sulbactam was 41.74 (23). Moreover, Williams et al. reported that DDD/100 bed-days of amikacin and metronidazole were 8.15 and 14.65, respectively, which was higher than our study (24). Nevertheless, Patel et al. reported that DDD/100 bed-days of ceftriaxone and cefotaxime were like our study (25).

The types of patients admitted to each ICU differ, which can influence the choice of antibiotic. Different ICUs may have varying antibiotic stewardship protocols, which can impact drug selection and utilization. Patients admitted to ICUs frequently get multiple broad-spectrum antibiotics at admission due to their increased severity, exposure to several invasive procedures, and susceptibility to multidrug-resistant bacteria. However, these prescriptions are often empiric and based on physician comfort and prior experience, often leading to overuse or misuse of antibiotics.

This study has some limitations, the most important of which is represented by the small sample size. Irrational use of antibiotics may also have been prevalent; however, it is difficult to judge due to the lack of available detailed clinical information. Moreover, the susceptibility pattern should have been recorded to better explain the antibiotic consumption.

Conclusion

The findings of the present study showed that the utilization of different antibiotics varied according to the type of ICU and disease. Penicillin combinations, cephalosporin, and carbapenems were the most commonly used antibiotic groups in all ICUs. High consumption of broad-spectrum antibiotics underscores the importance of stewardship programs to overcome the growing resistance to available effective antibiotics in ICUs.

Conflict of Interests

The authors declare no conflict of interests.

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