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Original Research Article

A Retrospective Study of Antibiotic Usage in ICU Patients

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Abstract:

Background: Drug utilization studies are essential for evaluating prescribing patterns and promoting rational antimicrobial use, particularly in Intensive Care Units (ICUs), where critically ill patients are exposed to high antibiotic use and risk of antimicrobial resistance.

Aim: To assess the pattern and rationality of antibiotic usage in ICU patients using WHO ATC/DDD methodology.

Methodology: A retrospective observational study was conducted over six months in Department of Pharmacology, Shree Narayan Medical institute and Hospital, Saharsa, Bihar, India. A total of 100 ICU patient records were analyzed for demographic details, antibiotic prescribing patterns, and utilization expressed as DDD/100 bed-days.

Results: The majority of patients were aged 21–40 years, with medical conditions being the most common indication for ICU admission. The average number of drugs per prescription was 3.52, with 2.7 antimicrobials per patient, indicating polypharmacy. Fixed-dose combinations constituted 52% of prescriptions. Meropenem (15 DDD/100 bed-days) and piperacillin-tazobactam (13.2) were most utilized. Most antibiotics were administered parenterally (76%). Dosing was largely consistent with WHO standards.

Conclusion: Antibiotic use in ICU patients is high, with frequent use of broad-spectrum and combination therapies. Continuous monitoring is necessary to ensure rational use and prevent antimicrobial resistance.

Keywords: Antibiotic Utilization, ICU, ATC/DDD, Antimicrobial Resistance, Polypharmacy, Retrospective Study.

Introduction

Drug utilization studies (DUS) are central in assessing, interpreting, and enhancing trends of drug use in healthcare systems. Such studies will be crucial in evaluating prescribing patterns, rational use of drugs and reducing inappropriate therapy. The World Health Organization (WHO) defines drug utilization as the marketing, distribution, prescription, and use of drugs within the society with particular attention given to the medical, social and economic implications of these drugs [1]. The end goal of these studies is to facilitate rational pharmacotherapy, improve the outcomes of the therapeutic process, minimize the adverse drug reaction, and guarantee maximum use of health care resources.

The Intensive Care Unit (ICU) is a very specialized and highly resource-demanding environment with critically ill patients who need constant attention, life-support therapy, and intensive pharmacological care. Patients who get admitted in ICUs are usually extremely infected, have a dysfunction of more than one organ, or have conditions that are life-threatening in nature and require the use of various medications concurrently. As a result, polypharmacy, disturbed pharmacodynamics and pharmacokinetics, and the compoundness of treatment regimens put ICU patients at a much greater risk of medication errors, adverse drug reactions [2]. Antimicrobial agents (AMAs) are some of the most commonly prescribed types of drugs in the ICUs [3] among the numerous classes of drugs.

The use of antimicrobials in ICUs is significantly increased as compared to other hospital wards. It has been stated that the use of antimicrobials in ICU is almost ten times more than in general wards [4]. This increased use can be explained by a number of factors including high rates of severe infections, immediate empirical treatment, and widespread use of invasive equipment like mechanical ventilators, central venous catheters, urinary catheters. These life-saving interventions also put pressure on the risk of hospital-acquired infections, therefore, requiring the use of more antimicrobials. Moreover, research like

that by Weber et al. has also shown that the cost of drugs used in ICU constitutes a large share of the total hospital drug cost (antimicrobial agents amount to 38.4% of it in comparison with 12% in non-ICU setting) [5]. This highlights the considerable financial implications of ICU pharmacotherapy.

The susceptibility of critically ill patients to infections is especially high because of a range of factors such as underlying comorbidities, immunosuppression, extended hospital stays, and exposure to invasive diagnostic and treatment measures. Subsequently, such patients experience high antimicrobial pressure [6]. Antimicrobial therapy in ICUs usually commences empirically in most instances where it is sometimes based on the experience of the clinician and not on conclusive microbiological data. Although empirical therapy is required in life-threatening scenarios, it can result in the wrong choice of drugs, their inappropriate dosing, and increased chances of resistance.

Also, the pharmacokinetic and pharmacodynamic characteristics of medications in patients in the ICU are considerably changed because of the dysfunctions of organs, changes in fluid distribution, a change in protein binding, and drug-drug interactions. Such alterations make optimization of doses difficult and can lead to therapeutic failure or even adverse drug reactions [7]. Thus, the close observation and rationalization of antimicrobial therapy are crucial in the ICUs.

The resource of ICUs and coronary care units (CCUs) occupy a large proportion of resources in hospitals, in part because of the high frequency of use of expensive drugs, most notably the broad-spectrum antimicrobials. Such irrational prescription of costly antimicrobial agents in developing areas like Bihar, India is a serious predicament to the already one-sided healthcare systems. The burden is further compounded by limited financial resources, a large number of patients, and poor infrastructure. Therefore, to make sure that the available resources are used fairly and efficiently, rational prescribing practices are essential. Drug utilization assessment is a valuable instrument that can be used to detect improper prescribing behavior and develop specific interventions to maximize the use of antimicrobial treatment.

ICUs have likewise been identified as locations of emergence and transmission of antimicrobial resistance (AMR) which is a significant global public health issue [8]. Excessive and inappropriate use of antimicrobial agents are involved in creating resistant pathogens, which results in the increase of morbidity, mortality, the lengthening of the hospital stays, and the increase of healthcare expenses. Although approximately 5000 antimicrobial agents have been identified, only about 100 are currently in active clinical use [9]. Additionally, the past few years have seen a significant decrease in the development of new antimicrobial agents which further reduces treatment options. It therefore follows that clinicians will be forced to largely depend on the currently available antimicrobial classes in the predictable future [10]. This highlights the great need to use available antimicrobials prudently to maintain their effectiveness.

Since dosing schedule, frequency, and route of administration vary across antimicrobial agents, a standardized approach is imperative in evaluation of drug use. WHO proposed Anatomical Therapeutic Chemical/Defined Daily Dose (ATC/DDD) system offers a universally recognized system of such assessments. The system is developed and maintained by the WHO Collaborating Centre for Drug Statistics Methodology, and this tool allows comparing the drug usage in various hospitals, regions, and countries in terms of standardized units [11].

Defined Daily Dose (DDD) can be described as the supposed average maintenance dose per day of a drug when utilized in the primary indication in adults. The concept deals with the shortcomings of conventional indicators of drug use by offering a unit of consumption fixed regardless of drug price, dose form or strength. The most common measure of antimicrobial use is DDD per 100 bed-days, which is commonly used to compare consumption of antibiotics in the hospital and outpatient environments. These standardized data are crucial to both track national and international trends related to the use of antimicrobials and to measure their correlation with the trends associated with antimicrobial resistance [12].

Periodic assessment of drug consumption patterns in ICUs is critical in improving the quality of healthcare delivery, rational use of drugs, and promoting patient outcomes. Monitoring antimicrobial use continuously assists in the detection of improper antimicrobial prescribing, encourages compliance with clinical guidelines and facilitates antimicrobial stewardship initiatives. They are especially relevant in the resource-restricted environment where optimization of drug use can make a major difference both in clinical and financial terms.

In this regard, the current retrospective study was developed with the objective of assessing the trend of antimicrobial use, and the sanity of their prescription in the ICU of a healthcare institution in Bihar, India. The research will determine the most frequently prescribed antimicrobial agents and measure their use through the WHO-recommended ATC/DDD methodology which will be in the form of DDD per 100 bed-days. The results of the present study are likely to help yield useful information on the current prescribing patterns and help in formulating a strategy to optimize antimicrobial therapy in an ICU environment.

Methodology

Study Design: The present study was designed as a retrospective, observational study to evaluate the pattern of antibiotic utilization among patients admitted to the Intensive Care Unit (ICU). Since the study was retrospective in nature, it involved review and analysis of previously recorded patient data without any direct intervention or modification in the treatment provided to the patients. The observational design was chosen to assess the existing prescribing trends and utilization pattern of antibiotics in ICU patients.

Study Area: The study was conducted in the Department of Pharmacology, Shree Narayan Medical Institute and Hospital, Saharsa, Bihar, India. This institution is a tertiary care teaching hospital that provides comprehensive healthcare services, including critical care management through its Intensive Care Unit. The Department of Pharmacology served as the coordinating department for the study, and patient records were obtained from the hospital's Medical Records Department.

Study Duration: The study was carried out over a period of six months. During this period, retrospective data from ICU patients admitted within the selected duration were collected, reviewed, and analyzed. The defined study duration ensured adequate availability of patient records and facilitated comprehensive assessment of antibiotic prescribing practices in the ICU.

Sample Size: A total of 100 patient case records were included in the study. The sample size consisted of medical records of ICU patients who fulfilled the predefined inclusion criteria. Only those records containing complete information regarding antibiotic prescriptions and other relevant clinical details were considered for analysis.

Study Population: The study population comprised all patients admitted to the Intensive Care Unit of Shree Narayan Medical Institute and Hospital during the study period. Patients of all age groups and both genders were included in the study. The population represented critically ill patients requiring intensive monitoring and treatment, among whom antibiotics are frequently prescribed.

Data Collection: Data for the study were collected retrospectively from the Medical Records Department after obtaining the necessary administrative permission and ethical approval. A predesigned and structured data collection proforma was used to obtain relevant information from the selected patient records. The collected data included demographic details such as age and gender, diagnosis and indication for ICU admission, duration of ICU stay, number of drugs prescribed, and details related to antibiotic therapy. Information regarding the class of antibiotics prescribed, number of antibiotics per patient, route of administration, use of fixed-dose combinations, availability of culture and sensitivity reports, and clinical outcome was also recorded. Only complete and legible records were used in order to maintain the accuracy and reliability of the study findings.

Inclusion Criteria

- Medical records of patients admitted to the ICU during the study period
- Patients of all age groups and both genders
- Medical records containing complete information on antibiotic prescriptions

Exclusion Criteria

- Incomplete or illegible medical records
- Patients admitted to wards other than ICU
- ICU stay of less than 24 hours
- Records lacking antibiotic prescription details

Procedure: The study was conducted in three phases. In the first phase, the study protocol was prepared after reviewing relevant literature related to antibiotic utilization in ICU patients. A structured data collection proforma was designed, and the study proposal was submitted to the Institutional Ethics Committee for approval. After obtaining ethical clearance, permission was obtained from the hospital authorities and Medical Records Department for access to patient files.

In the second phase, patient records were reviewed retrospectively and the required information was extracted using the prepared proforma. The prescribed antibiotics were classified according to the Anatomical Therapeutic Chemical (ATC) classification system. Antibiotic utilization was further assessed using the Defined Daily Dose (DDD) methodology recommended by the World Health Organization. The extent of antibiotic consumption was expressed as DDD per 100 bed-days, and prescribed daily doses were compared with standard DDD values wherever applicable.

In the final phase, the collected data were compiled and analyzed. The results were interpreted to identify patterns of antibiotic prescribing and utilization in ICU patients. The study findings were then documented systematically, limitations were identified, and the final manuscript was prepared.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using descriptive statistical methods. Frequencies and percentages were used to summarize categorical variables such as gender distribution, types of antibiotics prescribed, route of administration, and use of fixed-dose combinations. Continuous variables such as age, duration of ICU stay, and number of antibiotics prescribed per patient were expressed as mean values with standard deviation wherever applicable. Tables and charts were used to present the findings

in a simple and clear manner. The analysis primarily focused on describing the pattern and extent of antibiotic utilization in ICU patients rather than making inferential statistical comparisons."

Result

Table 1 presents the demographic distribution of patients admitted to the ICU according to indication, age, and sex (N=100). Medical causes accounted for the highest admissions, particularly in the 21–40 years (20) and 41–60 years (16) age groups, with a slightly higher proportion of males (28) compared to females (22). Surgical admissions were also notable, mainly in the 21–40 years (10) group, with more males (16) than females (10). Orthopaedic cases were relatively fewer and equally distributed between males and females (6 each). Obstetric and gynecological (OBG) admissions were exclusively among females (16), predominantly in the 21–40 years (12) and <20 years (4) age groups. Overall, the majority of patients belonged to the 21–40 years age group (46), followed by 41–60 years (28), with a slightly higher number of female patients (54) compared to males (50).

Table 1: Patient Demographics (N = 100)

Indication for ICU Admission	< 20 years	21–40 years	41–60 years	> 60 years	Male	Female
Medical	6	20	16	8	28	22
Surgical	4	10	8	4	16	10
Orthopaedic	2	4	4	2	6	6
OBG	4	12	0	0	0	16
Total	16	46	28	14	50	54

Table 2 presents the pattern of drug use based on ATC/DDD indicators among the study population (N=100). The average number of drugs per prescription was 3.52, with a relatively high average of 2.7 antimicrobial drugs per prescription, indicating frequent use of multiple antibiotics. More than half of the drugs (52.00%) were prescribed as antimicrobial fixed-dose combinations (FDCs), suggesting a preference for combination therapy. Additionally, 44.00% of prescriptions included an oral drug, indicating that less than half of the treatments involved oral administration, with the remainder likely relying on parenteral routes. Overall, the findings reflect a moderate level of polypharmacy and a high reliance on antimicrobial combinations in clinical practice.

Table 2: Pattern of Drug Use as per ATC / DDD Indicators (N = 100)

Drug Use Indicators	Results
Average number of drugs per prescription	3.52
Average number of antimicrobial drugs per prescription	2.7
Percentage of drugs containing antimicrobial FDCs	52.00%
Percentage of prescriptions with an oral drug prescribed	44.00%

Table 3 presents the pattern of antibiotic utilization based on WHO ATC/DDD classification among the study population (N=100). Meropenem showed the highest utilization with 15 DDD/100 bed days and a PDD/DDD ratio of 1.15, indicating slightly higher prescribed doses than standard. This was followed by Piperacillin + Tazobactam (13.2 DDD/100 bed days; PDD/DDD 1.07) and Ceftriaxone (10.5; 1.05). Cefoperazone + Sulbactam and Amoxicillin + Clavulanic acid had PDD/DDD ratios of 1, indicating appropriate dosing. Slightly lower than standard dosing was seen with Metronidazole (0.93), Vancomycin (0.9), and Amikacin (0.75). Azithromycin and Levofloxacin showed near-standard utilization with PDD/DDD ratios of 1.04 and 1.1 respectively. Overall, broad-spectrum antibiotics like meropenem and piperacillin-tazobactam were the most utilized, with most drugs showing dosing close to WHO standards.

Table 3: Pattern of Antibiotic Utilization as per WHO ATC / DDD Classification (N = 100)

Antibiotic	ATC Code	WHO DDD (g)	PDD (g)	DDD/100 Bed Days	PDD/DDD
Cefoperazone + Sulbactam	J01DD62	4	4	8.1	1
Piperacillin + Tazobactam	J01CR05	14	15	13.2	1.07
Ceftriaxone	J01DD04	2	2.1	10.5	1.05
Meropenem	J01DH02	2	2.3	15	1.15
Metronidazole	J01AF01	1.5	1.4	7.2	0.93
Amoxicillin + Clavulanic acid	J01CR02	3	3	5.8	1
Azithromycin	J01FA10	0.5	0.52	5.1	1.04
Amikacin	J01GB06	1	0.75	3.1	0.75

Vancomycin	J01XA01	2	1.8	3.9	0.9
Levofloxacin	J01MA12	0.5	0.55	2.1	1.1

Table 4 shows the distribution of routes of antibiotic administration among the study population (N=100). The majority of antibiotics were administered via the parenteral route, accounting for 76 prescriptions (76%), while the oral route was used in 24 prescriptions (24%). This indicates a clear preference for parenteral administration, likely reflecting the need for rapid and effective drug delivery in more severe or hospitalized cases.

Table 4: Distribution of Route of Antibiotic Administration (N = 100)

Route of Administration	Number of Prescriptions	Percentage (%)
Parenteral	76	76
Oral	24	24
Total	100	100

Discussion

The current retrospective study on the use of antibiotics in patients at ICU reveals both similar and different trends with the existing literature in the topic, thus offering a wider perspective on the use of antimicrobials in critical care units. Our results have shown that most ICU hospitalizations were found in the 21-40 years category (46%), then 41-60 years (28%), unlike other studies that reported elderly patients (>60 years) as the dominant (Shankar et al., 2010; Hamdi et al., 2013) [13,14]. This diversity brings out demographic and epidemiological disparities between regions. Like our results, Mahendra et al. (2013) [15] also found a disproportionate number of younger adults in ICU admissions in Indian environments which may be explained by the nature of infectious diseases, trauma, and acute medical conditions which impact economically productive age groups more in developing countries. In contrast, however, the studies in developed countries have always found higher rates of ICU admissions among older populations, which could be attributed to the longer life expectancy and increased chronic illnesses".

The gender composition in our study indicated that there was a moderate female dominance (54%), which is in line with the results of Mahendra et al. (2013) [15], even though the difference in their study was not that high. To a great extent, this similarity can be explained by the fact that in both studies, obstetric and gynecological cases were restricted to younger groups of females. Conversely, other studies that were carried out in the ICU like John et al. (2011) [16] indicated that the male population was predominant implying that the gender balance could be different across different ICUs and case mixes. The greater percent of females in our sample could also be due to the regional healthcare use patterns in which women are more likely to seek tertiary care in case of a reproductive health related condition.

Our study showed an average of 3.52 drugs per patient, which is similar to the results of the Williams et al. (2011) [7], who indicated that the average number of drugs per ICU patient was 3.8. This reflects moderate polypharmacy and a rather sensible approach to prescribing. Nevertheless, other studies like those by Weber et al. (2003) [5] and Anand et al. (2016) [10] have reported higher means of over five drugs in a patient, suggesting that polypharmacy is more widespread in certain ICUs. The relatively low figure of our study indicates the increased compliance with the principles of rational drug use, which reduces the potential risk of adverse drug reactions and drug interactions. However, moderate polypharmacy should also be subject to constant observation, particularly among the critically ill patients who are at a higher risk of complications.

The use of antimicrobials in our study was significantly high with a mean of 2.7 antimicrobials per prescription which is very similar to those of John et al. (2011) [16], who showed that there was extensive use of antimicrobials in the ICU. On a similar note, Curcio (2011) [8] found that the rates of antibiotic prescribing were high in Latin American ICUs, which confirmed the trend of over-reliance on antimicrobials in ICUs globally. Nevertheless, though our research indicated a slightly lower use of antimicrobials than the international research, it nevertheless highlights the critical need of antibiotics in the treatment of serious infections. Our high percentage of fixed-dose combinations (52) is also in line with Satya et al. (2006) [17] as they also found a high use of beta-lactam and beta-lactamase inhibitor combination. Conversely, previous literature showed a tendency to use narrower-spectrum combinations e.g., amoxicillin-clavulanic acid, but our results indicate a tendency to use broader-spectrum agents like piperacillin-tazobactam, which reflects the changing trends in resistance and prescribing.

Our study of the WHO ATC/DDD methodology analysis showed that meropenem was the most utilized drug (15 DDD/100 bed days), then the next were piperacillin-tazobactam and ceftriaxone. These results are closely similar to research conducted by Shankar et al. (2010) [13], Curcio (2011) [8], who also found the use of carbapenems and broad-

spectrum beta-lactams as the most frequently used antibiotics in the ICUs. Nevertheless, the general use of antibiotics in our study seems to be less than that of Hamdi et al. (2013) [14] who experienced much higher DDD/100 bed days in a Turkish hospital. This comparison can be an expression of a comparatively conservative use of antibiotics in our location or disparities in the severity of infections and hospital practices.

The PDD/DDD ratios of our study also support rational use of dosing with most antibiotics having a ratio of approximately unity. Minimally high ratios of meropenem (1.15) and piperacillin-tazobactam (1.07) are in line with the results of Hamdi et al. (2013) [14], in which a higher dose of these drugs was used in the critically ill because of the changes in pharmacokinetics and requirements of optimum levels of drug. On the other hand, reduced ratios of drugs such as amikacin and metronidazole in our study correlate with conservative dosing regimens in other studies to reduce the risk of toxicity. These parallels imply compliance to evidence-based dosing with flexibility depending on the state of a patient.

The use of parenteral routes (76% of the usage in our study) is in line with several other previous studies such as John et al. (2011) [16] and Shankar et al. (2003) [18] that found a high preference to use intravenous routes in the ICU. This similarity is a manifestation of the urgent necessity of the quick effect of drugs, stability in their absorption, and the strict control of their dosage in patients with acute illnesses. Nevertheless, even though the use of parenteral therapy is justified, literature highlights the need to have timely de-escalation to oral therapy as part of antimicrobial stewardship initiatives, which seems to be underutilized in our study, with only 24% of antibiotics being given orally.

In general, the results of our research show a trend of antibiotic use, which is mostly similar to national and international research, especially regarding high antimicrobial use, the tendency to use broad-spectrum agents, and the use of parenteral administration. Meanwhile, the significant variation in demographic composition, the extent of antibiotic use, and the trend in prescription points to the impact of regional influence, disease burden, and health care practices. Such comparisons underscore the importance of constant monitoring, following the principles of antimicrobial stewardship, and encouraging culture-directed therapy in order to maximize antibiotic use and overcome the increasing problem of antimicrobial resistance (Berrington, 2010) [12].

Conclusion

The current retrospective research demonstrates that the use of multiple antimicrobial agents is predominant among patients in ICUs due to the severity of diseases and the necessity of empirical treatment of the broad spectrum. The most common cause of ICU admissions was medical conditions, with a fairly even gender balance between cases. The patterns of antibiotic prescription displayed a strong tendency toward combination therapy, especially with fixed-dose combinations, suggesting a shift towards aggressive treatment of the infections. The most common group of antibiotics used was broad-spectrum meaning, either beta-lactam combinations or carbapenems; the use was closely related to the general dosing regimen, with slight deviation observed in certain instances. Parenteral delivery became the route of choice, in line with the severity conditions of patients in intensive care. Overall, the study underscores the importance of rational antibiotic use and the need for continuous monitoring to promote antimicrobial stewardship and minimize the risk of resistance in critically ill patients.

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