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Original Research Article

Antimicrobial usage in post operative patients in general surgery wards and intensive care units of a tertiary care hospital in central India: an ATC/DDD-based observational study

Girish K. Chavhan*, Jijo P. Abraham, Saiprasad A. Upadhyaya, Somesh P. Bokare

Department of Pharmacology, Government Medical College Akola, Maharashtra, India

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*Correspondence:

Dr. Girish K. Chavhan,

Email: girishchavhan949@gmail.com

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ABSTRACT

Background: The rise of antimicrobial resistance (AMR) is a major global health concern, due to inappropriate use of antibiotics. General surgery wards and intensive care units (intensive care units), are high-risk areas due to frequent use of antimicrobials for postoperative prophylaxis and treatment. This study focuses on assessing antimicrobial consumption patterns in postoperative patients using the world health organization (WHO) anatomical therapeutic chemical/defined daily dose (ATC/DDD) system.

Methods: A prospective, observational study was conducted over 12 months in the general surgery unit of tertiary care hospital. Antimicrobial usage data were collected from postoperative patients using WHO's ATC/DDD methodology and expressed as DDD/100 bed-days. Descriptive statistics were used for analysis, and ethical approval was obtained prior to study initiation.

Results: Out of 600 participants enrolled, majority were males (64.5%), 49.66% were in 18-40 age group, and majority (69.33%) were from rural areas. Most patients (47.5%) were prescribed two antibiotics. A total of nine antibiotics were commonly prescribed, with inj. metronidazole being the most frequently used (35.8%), followed by inj. amoxicillin + clavulanic acid (24.3%) and inj. cefotaxime (12.0%). According to WHO ATC/DDD methodology, inj. metronidazole showed the highest antibiotic consumption at 14.96 DDD/100 bed-days, followed by inj. amoxicillin + clavulanic acid at 7.17 DDD/100 bed-days.

Conclusions: Study highlights extensive antibiotic use (99.66%) in postoperative patients, with a predominance of injectable drugs (86.07%). Average of 2.12 antibiotics per patient suggests a trend toward broad-spectrum prophylaxis, raising concerns about costs, adverse effects, and resistance. The findings underscore the need for prescription audits and antimicrobial stewardship to improve rational and cost-effective drug use.

Keywords: Antimicrobial, Postoperative, ATC/DDD, DDD/100 bed days

INTRODUCTION

The rise of AMR poses a significant threat to global health, driven largely by inappropriate and excessive use of antibiotics. Hospital settings, particularly general surgery wards and ICUs, are high-risk zones for the overuse and misuse of antimicrobials, due to the high burden of postoperative infections and the critical nature of patients' conditions.^{1,2}

Postoperative patients are frequently prescribed antibiotics for both prophylaxis and treatment of infections.³ However, deviations from standard prescribing guidelines, such as extended duration of prophylaxis or empirical use without microbiological confirmation, contribute significantly to irrational drug use.⁴ This not only increases healthcare costs but also accelerates the development of resistant organisms.

To address this challenge, the WHO recommends the use of the ATC classification and the DDD methodology as a standardized tool for measuring drug utilization.⁵ This approach allows for cross-institutional and international comparisons of antimicrobial consumption, making it a valuable tool in antimicrobial stewardship programs.

DDDs provide a fixed unit of measurement independent of price, currencies, package size and strength enabling the researcher to assess trends in drug consumption and to perform comparisons between population groups.

The basic definition of the WHO DDD is: The DDD is the assumed average maintenance dose per day for a drug used for its main indication in adults.⁶

The DDD is a unit of measurement and does not reflect the recommended or prescribed daily dose. Therapeutic doses for individual patients and patient groups will often differ from the DDD as they will be based on the individual characteristics such as age, weight, ethnic differences, type and severity of disease.

Although several studies have assessed antibiotic usage patterns in ICUs and perioperative settings, there is limited data focusing specifically on postop period in both general surgery wards and ICUs within the Indian healthcare context. This gap highlights need for real-world, hospital-based studies that evaluate antimicrobial utilization using robust and internationally accepted methods.⁷⁻⁹

This study aims to evaluate the pattern of antimicrobial usage among postoperative patients admitted to general surgery wards and ICUs in a tertiary care hospital using the WHO ATC/DDD methodology. By providing insights into drug consumption trends, our study seeks to inform and support antimicrobial stewardship strategies and promote rational antibiotic use.

METHODS

Study design

This was a prospective and observational study design.

Study setting

The research was carried out in the general surgery unit of a tertiary care teaching hospital located in Central India. The study targeted postoperative patients admitted to the general surgery wards and the surgical intensive care unit (SICU). The general surgery unit comprises approximately 130 beds-60 each in the male and female surgery wards, and 10 beds in the SICU. On average, the unit handled around 1136 patient admissions per month.

Study material

Information was gathered from indoor postoperative adult patients in the general surgery wards and SICU through

direct interaction and review of their case records. Additional data on daily and monthly admissions during the 12-month study duration (365 days) was extracted from the surgical bed list book maintained in each of the respective wards and SICU. The investigator solely observed the treatment protocols without intervening in patient management. Antimicrobial agents were categorized using the WHO's ATC classification system, and their usage was measured using the DDD metric, reported as DDD per 100 bed-days. The DDD refers to the assumed average maintenance dose per day for a drug used for its main indication in adults.

Formula for calculating DDD/100 bed-days

Calculation of DDD/100 bed-days: $\text{DDD}/100 \text{ bed days} = \frac{\text{no. of units administered in a given period} \times 100}{\text{DDD} \times \text{no. of days} \times \text{no. of beds} \times \text{occupancy index}}$

Occupancy index

Calculated daily by dividing the number of beds occupied by the total number of available beds: $\text{occupancy index} = \frac{\text{No. of beds occupied}}{\text{Total no. of beds}}$.

Averaged daily values were used to compute the monthly occupancy index. The study considered 130 beds in total, and the mean occupancy index was determined to be 0.28.

Study population

The target population comprised adult postoperative patients admitted to the general surgery wards and SICU.

Inclusion criteria

Postoperative patients aged 18 years or older, patients admitted postoperatively in the general surgery department and followed until discharge. Only antimicrobials prescribed postoperatively were considered. Patients who consented to participate in the study.

Exclusion criteria

Case records lacking sufficient data as per the pre-designed format, patients who left against medical advice or absconded, patients who passed away during the postoperative period and critically ill postoperative patients were excluded.

Consent

Written informed consent was obtained either from the patient or their legally authorized representative.

Sample size

A total of 600 patients were included, in accordance with WHO recommendations for drug utilization studies.

Sampling technique

Convenient sampling was employed until the sample size was met.

Data source

Data were documented on a pre-structured case report form (CRF) during routine follow-ups of postoperative patients from admission to discharge in the general surgery wards and SICU.

Study duration

The study was conducted over a one-year period, from November 2018 to October 2019.

Ethical considerations

The study commenced following approval from the institutional ethics committee (Letter No.: GMCA/IEC/209/2018).

Data analysis plan

Data from the CRFs were compiled in Microsoft excel and analysed using descriptive statistics under the guidance of a statistician. Results were presented in terms of numbers and percentages. All medications were verified using the WHO model list of essential medicines.

RESULTS

During the study period, a total of 600 postoperative cases were observed in the general surgery inpatient wards and ICU. The majority of the patients were male (64.5%) (Table 1). Most patients (49.66%) belonged to the 18-40 years age group, followed by 41-60 years (26.16%) and >60 years (24.16%) (Table 1).

Most of the inpatient admissions in general surgery wards and ICU of the hospital were from rural background at 69.33% (416) (Table 1).

Antibiotic prescription patterns (Table 2)

Out of 600 patients: 47.5% (n=285) received 2 antibiotics, 24.83% (n=149) received 1 antibiotic, 21.33% (n=128) received 3 antibiotics, 5.33% (n=32) received 4 antibiotics,

0.33% (n=2) received 5 antibiotics, and 0.66% (n=4) were not prescribed any antibiotics.

Antibiotics prescribed

A total of nine antibiotics were commonly prescribed during the study. The most frequently prescribed drug was inj. metronidazole (n=395), followed by inj. amoxicillin + clavulanic acid (n=273) and cefotaxime (n=153) (Table 3).

ATC classification and WHO DDD

The prescribed antibiotics were classified using the ATC classification. WHO-defined DDD values and routes of administration are shown below (Table 4).

Antibiotic use (DDD/100 bed-days)

Antibiotic usage was measured as DDD/100 bed-days. The highest use was observed for Inj. metronidazole (14.96 DDD/100 bed-days), followed by inj. amoxicillin + clavulanic acid (7.17 DDD/100 bed-days) (Table 5).

Table 1: Demographic distribution of study participants, (n=600).

Variables	Category	N	Percentage (%)
Gender	Male	387	64.50
	Female	213	35.50
Age group (in years)	18-40	298	49.66
	41-60	157	26.16
	>60	145	24.16
Residence	Rural	416	69.33
	Urban	184	30.66

Table 2: Number of antibiotics prescribed per encounter.

No. of antibiotics prescribed	N	Percentage (%)
0	4	0.66
1	149	24.83
2	285	47.50
3	128	21.33
4	32	5.33
5	2	0.33
Total	600	100

Table 3: Antibiotics prescribed during the study period.

Antibiotic	Route	No. of prescriptions	Percent (%)	Drug use (gm)
Inj. metronidazole	IV	395	35.8	2983
Tab metronidazole	Oral	61		249.6
Inj. amoxicillin + clavulanic acid	IV	273	24.3	2860.8
Tab amoxicillin + clavulanic acid	Oral	37		91.5
Inj. cefotaxime	IV	153	12.0	1150
Inj. piperacillin + tazobactam	IV	92	7.2	4212
Inj. cefoperazone + sulbactam	IV	88	6.9	1404

Continued.

Antibiotic	Route	No. of prescriptions	Percent (%)	Drug use (gm)
Inj. ciprofloxacin	IV	30	8.6	38.4
Tab ciprofloxacin	Oral	80		200
Inj. amikacin	IV	31	2.4	224.5
Inj. gentamicin	IV	28	2.2	44
Inj. cefoperazone	IV	6	0.5	10

Table 4: ATC codes and WHO DDDs of prescribed antibiotics.

Antibiotic	ATC Code	DDD	Route
Inj. metronidazole	J01XD01	1.5 gm	P
Tab metronidazole	P01AB01	2 gm	O
Inj. amoxicillin + clavulanic acid	J01CR02	3 gm	P
Tab amoxicillin + clavulanic acid	-	1.5 gm	O
Inj. cefoperazone + sulbactam	J01DD12	4 gm	P
Inj. piperacillin + tazobactam	J01CR05	14 gm	P
Inj. cefotaxime	J01DD01	4 gm	P
Inj. amikacin	J01GB06	1 gm	P
Inj. ciprofloxacin	J01MA02	0.8 gm	P
Tab ciprofloxacin	-	1 gm	O
Inj. gentamicin	J01GB03	0.24 gm	P
Inj. cefoperazone	J01DD12	4 gm	P

P-Parenteral and O-Oral

Table 5: Antibiotic usage in DDD/100 bed-days over 365 days.

Antibiotic	DDD/100 bed-days
Inj. metronidazole	14.96
Tab metronidazole	0.93
Inj. amoxicillin + clavulanic acid	7.17
Tab amoxicillin + clavulanic acid	0.45
Inj. cefoperazone + sulbactam	2.64
Inj. piperacillin + tazobactam	2.26
Inj. cefotaxime	2.16
Inj. amikacin	1.68
Inj. ciprofloxacin	0.36
Tab ciprofloxacin	1.50
Inj. gentamicin	1.37
Inj. cefoperazone	0.01

DISCUSSION

Data of 600 patients matching the inclusion criteria, who underwent surgery and remained in the post-operative period until discharge from the surgery ward of our tertiary care teaching hospital, were collected.

The largest proportion of patients were males-387 (64.5%)-which is in accordance with studies conducted by Alam et al (63.2%) and Kumar et al (61.77%).^{10,11}

In this study, a total of 298 (49.66%) patients belonged to the age group of 18-40 years. A similar trend was observed in the studies by Alam et al. (63%) and Patil et al (62.96%), where the majority of patients were under 40 years of age.^{10,12} This is expected, as this is the productive age group actively involved in socioeconomic activities, making them more vulnerable to diseases requiring surgical interventions.

Out of the 600 participants, 598 (99.66%) received antimicrobial agents. This is comparable to the study by Kumar et al (100%).¹¹ The use of antibiotics in post-operative patients is primarily prophylactic, aimed at preventing surgical site infections.

The most commonly prescribed drugs in the general surgery IPD were ranitidine (14.10%), followed by ondansetron (10.59%), tramadol (10.54%), metronidazole (10.27%), Ringer's lactate (8.97%), normal saline (8.20%), amoxicillin and clavulanic acid (6.98%), dextrose with normal saline (5.54%), paracetamol (5.02%), cefotaxime (3.44%), ciprofloxacin (2.47%), piperacillin and tazobactam (2.07%), cefoperazone and sulbactam (1.98%), 5% dextrose (1.98%), and multivitamins and minerals (1.80%).

Among the total of 4437 drugs prescribed, 86.07% (3819) were injections, while 13.92% (618) were oral drugs.

The overall percentage of drugs prescribed by generic name in the present study was 41.08%, which is comparable with the study by Choudhury et al (41.6%).¹³ This indicates that more than half of the drugs were prescribed by brand names, contributing to increased therapy costs. Promoting generic prescribing can rationalize drug use and significantly reduce costs.

In this study, 28.65% of drugs were in the form of fixed dose combinations (FDCs), which is higher than reported by Kumar et al (12.42%).¹¹ Most of the FDCs prescribed were rational.

Among all prescriptions analysed, the most common class of drugs prescribed by surgeons were antimicrobials (28.71%), followed by intravenous fluids (24.70%), analgesics (16.58%), antacids (14.91%), and antiemetics (10.59%). The most extensively prescribed drugs in each category were inj. metronidazole, Ringer's lactate, inj. tramadol, inj. ranitidine, and inj. ondansetron, respectively.

Post-operative pain is one of the most common complaints after surgery. Therefore, analgesic use has become almost essential post-operatively. The most commonly used analgesic in this study was tramadol (63.58%), followed by paracetamol (30.29%) and diclofenac (6.11%).

The average number of antibiotics used per patient in the present study was 2.12, which is higher than that reported by Kumar et al (1.55).¹¹ This higher number reflects a trend toward prophylactic antibiotic use as blanket therapy rather than for definitive treatment. While this approach aims to prevent infections, it increases therapy costs, risk of adverse drug reactions, and the development of drug-resistant bacterial strains.

Out of 4437 drugs prescribed, 1274 (28.71%) were antibiotics. This finding aligns with studies by Mandal et al (30%) and Kumar et al (37.89%).^{11,14}

Metronidazole was the most commonly used antibiotic in the present study.

A total of nine different antibiotics were commonly prescribed to post-operative patients in the general surgery unit. The most frequently prescribed antibiotic was inj. metronidazole (395 prescriptions), followed by inj. amoxicillin and clavulanic acid (273), inj. cefotaxime (153), inj. piperacillin and tazobactam (92), inj. cefoperazone and sulbactam (88), and tablet ciprofloxacin (80). The prophylactic use of antibiotics such as cefotaxime and cefoperazone (third-generation cephalosporins) is in accordance with the ASHP therapeutic guidelines, which recommend cephalosporins due to their activity against anaerobic bacteria, providing protection against surgical wound infections.¹⁵

The highest antibiotic usage measured in defined daily dose per 100 bed-days (DDD/100 bed-days) was for inj.

metronidazole at 14.96, followed by inj. amoxicillin + clavulanic acid at 7.17, inj. cefoperazone + sulbactam at 2.64, inj. piperacillin + tazobactam at 2.26, and inj. cefotaxime at 2.16. In comparison, the study by Noviyanti I. Panu et al reported the highest usage for Ceftriaxone (27.54 DDD/100 bed-days), followed by cefadroxil (25.51 DDD/100 bed-days).¹⁶

CONCLUSION

This prospective observational study conducted in the general surgery department of a tertiary care teaching hospital provides valuable insights into the patterns of drug use, particularly antibiotics, in the postoperative period. The study reveals a high prevalence of antimicrobial prescribing (99.66%), with a majority of drugs administered in injectable form (86.07%). Metronidazole emerged as the most frequently used antibiotic, both in terms of prescription frequency and defined daily dose per 100 bed-days (14.96 DDD/100 bed-days).

The average number of antibiotics prescribed per patient (2.12) suggests a trend toward broad-spectrum prophylactic therapy, raising concerns about increased treatment costs, potential adverse drug reactions, and the risk of AMR. Although many fixed-dose combinations were rational, their overall use (28.65%) and the low rate of generic prescribing (41.08%) highlight areas where prescribing practices can be improved to promote cost-effective and rational drug use.

Overall, the study emphasizes the critical need for regular prescription audits and the implementation of antimicrobial stewardship programs. These measures can help optimize antibiotic use, minimize the emergence of resistance, and ensure safe and effective postoperative care.

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