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A STUDY TO ASSESS THE PREVALENCE OF CARBAPENEM RESISTANT ORGANISMS IN ICU/IPD PATIENTS AND THEIR OUTCOME IN A TERTIARY CARE HOSPITAL.

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Abstract

Background: Carbapenem-resistant organisms (CROs) are an emerging threat in healthcare settings, particularly among critically ill patients. This study assessed the prevalence of carbapenem-resistant organisms among ICU/IPD patients and evaluated their outcomes in a tertiary care hospital. ***Methods:*** A prospective observational study was conducted among 165 admitted patients with infective etiologies over 18 months. Clinical specimens were processed according to CLSI guidelines, and antimicrobial susceptibility testing was performed. ***Results:*** Overall CRO prevalence was 57.6%. Carbapenem-resistant Enterobacteriaceae (CRE) was the predominant resistant isolates followed by carbapenem-resistant Acinetobacter baumannii (CRAB). Resistance to ertapenem, imipenem, and meropenem was 93.9%, 89.7%, and 81.2%, respectively. Mortality was 4.2%, and all deaths occurred among ICU patients. ***Conclusion:*** A high burden of carbapenem resistance was observed, emphasizing the need for antimicrobial stewardship, strict infection-control measures, and surveillance programs.

Keywords: Carbapenem resistance, CRO, CRE, CRAB, ICU, antimicrobial resistance.

INTRODUCTION

Antimicrobial resistance (AMR) has become one of the most serious global health concerns in modern medicine.[1] Carbapenems are broad-spectrum beta-lactam antibiotics used as last-resort therapy against multidrug-resistant gram-negative bacteria.[2] However, extensive and irrational use of these antibiotics has accelerated the emergence of carbapenem-resistant organisms (CROs), especially in intensive care units.[3]

Carbapenem resistance mainly occurs through carbapenemase production, porin loss, efflux pump overexpression, and plasmid-mediated resistance mechanisms.[4] Common carbapenemases include KPC, NDM, VIM, IMP, and OXA-48 enzymes.[5]

The World Health Organization has classified carbapenem-resistant Enterobacterales, Acinetobacter baumannii, and Pseudomonas aeruginosa as critical-priority pathogens due to their increasing prevalence and limited therapeutic options.[6] In India, carbapenem resistance among Klebsiella pneumoniae and Acinetobacter baumannii has increased substantially in recent years.[7] These infections are associated with prolonged hospitalization, increased healthcare costs, therapeutic failure, and higher mortality.[8]

Despite the growing burden, limited institution-specific data are available from northern India. Therefore, this study was undertaken to determine the prevalence of carbapenem-resistant organisms among ICU/IPD patients and to evaluate their clinical outcomes.

AIM AND OBJECTIVES

Aim: To assess the prevalence of carbapenem-resistant organisms in admitted ICU/IPD patients and evaluate patient outcomes.

Objectives:

1. to determine the prevalence of carbapenem resistance among gram-negative isolates.
2. To assess the antibiotic susceptibility pattern of carbapenem-resistant organisms.
3. To evaluate clinical outcomes including discharge, recovery, and mortality.

MATERIALS AND METHODS

This prospective observational study was conducted at KD Medical College Hospital and Research Centre, Mathura, Uttar Pradesh, over a period of 18 months after approval from the Institutional Ethics Committee.

A total of 165 adult patients admitted in ICU/IPD with confirmed or suspected infective etiologies were included after obtaining informed consent. Patients admitted for non-infective conditions and outpatients were excluded from the study. Sample size was calculated using the formula:

$$N = (Z^2 \times p \times q) / e^2$$

Based on a pilot study from KIMS, Bhubaneswar (Verma G et al., 2022)9, which reported an overall carbapenem resistance prevalence of 30% among key gram-negative pathogens, the following parameters were applied: p = 30%, q = 70%, Z = 1.96 (95% confidence), e = 7% (acceptable margin of error), yielding N ≈ 165. Accordingly, a minimum of 165 eligible patients were targeted for enrolment using consecutive sampling.

Clinical specimens including blood, urine, sputum, pus, ET secretions, CSF, and body fluids were collected aseptically and processed according to standard microbiological procedures. Antimicrobial susceptibility testing was performed according to CLSI guidelines. Carbapenemase detection was done using Modified Hodge Test, Carba NP test and combined Disc test.

Data were analyzed using IBM SPSS version 29.0. Categorical variables were expressed as percentages, and $p < 0.05$ was considered statistically significant.

RESULTS

Distribution of Microbiological Samples

Table 1: Distribution of Microbiological Samples Collected

Type of Sample	Number (n=165)	Percentage (%)
Pus Culture (Pus C/S)	46	27.9%
Blood Culture (Blood C/S)	34	20.6%
Sputum Culture (Sputum C/S)	33	20.0%
Urine Culture (Urine C/S)	31	18.8%
Tracheal Secretions / ET C/S	11	6.7%
Vaginal Swab	6	3.6%
Body Fluids (CSF, Ascitic, Synovial)	3	1.8%
Tissue	1	0.6%
Total	165	100%

Pus culture was the most commonly submitted specimen (27.9%), pointing to the high prevalence of wound and soft-tissue infections. Blood, sputum, and urine cultures followed closely, jointly constituting over 79% of all specimens.

Tracheal secretions, vaginal swabs, body fluids, and tissue samples collectively accounted for a minor proportion, reflecting their role as site-specific diagnostic additions in select clinical scenarios.

Distribution of Isolated Microorganisms

Table 2: Distribution of Microorganisms Identified in All Collected Samples

Organism Isolated	Number (n=165)	Percentage (%)
Enterobacteriaceae		
Escherichia coli (including ESBL strains)	55	33.3%
Klebsiella pneumoniae (including ESBL/CRE strains)	42	25.5%
Klebsiella spp.	25	15.2%
Klebsiella oxytoca (including ESBL strains)	12	7.3%
Non-Fermenters		
Acinetobacter spp.	16	9.7%
Acinetobacter baumannii	10	6.1%
Pseudomonas aeruginosa / spp.	4	2.4%
Other		
Haemolytic Streptococci	1	0.6%
Total	165	100%

Gram-negative organisms dominated the microbiological profile. Enterobacterales accounted for approximately 81.3% of all isolates, with E. coli (33.3%) and K. pneumoniae (25.5%) being the two most prevalent pathogens. Non-fermenters — primarily Acinetobacter species and P. aeruginosa — constituted 18.2% of isolates. A single gram-positive organism (Haemolytic Streptococci) was identified, underscoring the overwhelmingly gram-negative character of infections in this cohort.

Prevalence of Carbapenem-Resistant Organisms

Table 3: Prevalence and Category of Carbapenem-Resistant Organisms (CRO)

Resistance Category	Number (n=165)	% of Total	% of CR Isolates (n=95)
Carbapenem Resistant Enterobacteriaceae (CRE)	54	32.7%	56.8%
CRE + ESBL (Co-resistance)	5	3.0%	5.3%
Carbapenem Resistant A. baumannii (CRAB)	33	20.0%	34.7%
Carbapenem Resistant P. aeruginosa (CRPA)	2	1.2%	2.1%
Carbapenem Resistant (other)	1	0.6%	1.1%
Total CRO	95	57.6%	100%
ESBL (without Carbapenem Resistance)	39	23.6%	–
Susceptible	30	18.2%	–
MDR Gram-Positive	1	0.6%	–

A total of 95 out of 165 isolates (57.6%) were carbapenem-resistant, indicating a high institutional resistance burden. CRE was the predominant category (56.8% of CR isolates), followed by CRAB (34.7%). CRPA was identified in only 2 cases. CRE with concurrent ESBL co-production was documented in 5 isolates, representing a therapeutically challenging dual-resistance phenotype. Only 18.2% of isolates remained fully susceptible to tested antibiotics.

Carbapenem Resistance Pattern by Organism

Table 4: Carbapenem Resistance Pattern by Organism

Organism	CRE	CRAB	CRPA	CRE+ESBL	Total CR
Escherichia coli	24	7	0	2	33
Klebsiella pneumoniae	18	3	0	3	24
Klebsiella spp.	11	3	0	0	14
Acinetobacter spp.	0	9	0	0	9
Acinetobacter baumannii	0	5	0	0	5
Klebsiella oxytoca	1	3	0	0	4
Pseudomonas aeruginosa/spp.	0	0	2	0	2
Others	0	3	0	0	3
Total	54	33	2	5	95

E. coli contributed the greatest number of carbapenem-resistant strains (n=33), predominantly through the CRE phenotype. K. pneumoniae followed with 24 resistant isolates, carrying both CRE and CRE+ESBL phenotypes. Acinetobacter species

were exclusively CRAB, collectively accounting for 14 resistant isolates. P. aeruginosa resistance was limited to CRPA (n=2). CRE was the most prevalent overall phenotype (n=54), with CRAB second (n=33).

Antibiotic Management Strategies

Table 5: Antibiotic Management Strategies Following Culture Sensitivity Reports

Antibiotic Management Strategy	Number (n=165)	Percentage (%)
Antibiotics adjusted per clinical response	70	42.4%
Antibiotic escalated per sensitivity report	26	15.8%
Escalated to Colistin + Tigecycline	26	15.8%
Escalated to Tigecycline + Fosfomycin	22	13.3%
Escalated to Colistin + Fosfomycin	7	4.2%
Escalated to Polymyxin-B + Rifampicin	6	3.6%
Escalated to Colistin + High-dose Meropenem	4	2.4%
De-escalated to targeted therapy	2	1.2%
Escalated to Colistin / Ceftolozane-Tazobactam	2	1.2%
Total	165	100%

Clinical-response-guided antibiotic adjustment was the most frequently employed strategy (42.4%), reflecting pragmatic decision-making particularly in time-pressured ICU settings. Sensitivity-guided escalation and Colistin+Tigecycline combination therapy were equally used (15.8% each), representing primary approaches for extensively drug-resistant infections. Tigecycline+Fosfomycin served as the next most common salvage option (13.3%). De-escalation to targeted narrow-spectrum therapy was rarely feasible (1.2%), reflecting the limited susceptibility preserved in this patient population.

Clinical and Final Outcome

Table 6: Clinical and Final Outcome

Clinical Outcome	Number (n=165)	Percentage (%)
Intermediate Clinical Outcome		
Improved and shifted to ward	98	59.4%
Improved and discharged	50	30.3%
Deteriorated	17	10.3%
Final Outcome (at Discharge)		
Discharged (alive)	158	95.8%
Expired (mortality)	7	4.2%
Total	165	100%

Overall clinical outcomes were favourable: approximately 89.7% of patients showed intermediate improvement, either shifting to ward care (59.4%) or achieving direct discharge (30.3%). Clinical deterioration was recorded in 10.3% of cases. At final disposition, 95.8% (n=158) of patients were discharged alive, while in-hospital mortality was 4.2% (n=7). All deaths occurred among patients with severe, treatment-refractory infections, consistent with the high drug-resistance burden documented in this cohort.

Final Outcome Stratified by Resistance Category

Table 7: Final Outcome Stratified by Resistance Category

Resistance Type	Total (n)	Discharged (n/%)	Expired (n/%)	Mortality %
CRE	54	52 (96.3%)	2 (3.7%)	3.7%
CRE + ESBL	5	5 (100%)	0 (0%)	0%
CRAB	33	31 (93.9%)	2 (6.1%)	6.1%
CRPA	2	2 (100%)	0 (0%)	0%
ESBL (non-CR)	39	36 (92.3%)	3 (7.7%)	7.7%
Susceptible	30	30 (100%)	0 (0%)	0%
CR (Other)	1	1 (100%)	0 (0%)	0%
MDR Gram-Positive	1	1 (100%)	0 (0%)	0%
Total	165	158 (95.8%)	7 (4.2%)	4.2%

ESBL-producing non-carbapenem-resistant organisms carried the highest category-specific mortality (7.7%), followed by CRAB (6.1%) and CRE (3.7%). Zero mortality was recorded among susceptible isolates, CRE+ESBL, and CRPA subgroups.

DISCUSSION

The present study demonstrated a high prevalence of carbapenem resistance (57.6%), which is comparable with recent Indian surveillance studies.[7] CRE was the predominant resistant phenotype, followed by CRAB. Similar observations have been reported in other tertiary care studies from India.[9]

The predominance of gram-negative organisms, especially Escherichia coli and Klebsiella pneumoniae, highlights the growing burden of multidrug-resistant Enterobacterales in hospitalized patients. High resistance rates to carbapenems indicate near-complete loss of effectiveness of these antibiotics in critically ill patients. Combination therapies such as colistin with tigecycline were commonly used because of limited treatment options. De-escalation therapy was rarely possible due to extensive resistance patterns.

The overall mortality in the present study was lower compared to many ICU-focused studies. However, all deaths occurred among ICU patients, emphasizing the role of critical illness and severity of infection in determining outcomes. Similar studies have identified ICU stay and severity scores as important predictors of mortality.[10].

CONCLUSION

This prospective observational study, conducted over 18 months at a tertiary care centre in Mathura, Uttar Pradesh, examined CRO prevalence, antimicrobial susceptibility, and clinical outcomes among 165 patients admitted to the ICU and IPD with an infective aetiology. The study population was predominantly male (61.8%), with a mean age of 50.4 ± 18.8 years. More than half the patients required ICU-level care (57.0%).

The overall CRO prevalence was 57.6% (95/165), among the highest figures reported from tertiary care centres in northern India. CRE represented the largest resistance category (56.8%), followed by CRAB (34.7%), CRE with concurrent ESBL production (5.3%), and CRPA (2.1%). Resistance to all three tested carbapenem agents was substantial: ertapenem 93.9%, imipenem 89.7%, and meropenem 81.2%, reflecting near-complete loss of carbapenem utility.

In-hospital mortality was 4.2% (7/165). All deaths occurred in ICU-admitted patients, giving an ICU-specific mortality of 7.4%, while IPD patients had a 100% survival rate. Ward of admission was the sole statistically significant predictor of mortality (Fisher's exact p=0.021). Carbapenem resistance status itself was not independently associated with mortality (OR=0.98; p=1.000), indicating that clinical severity and care environment were the principal determinants of survival in this mixed cohort.

Collectively, these findings call for the immediate reinforcement of antimicrobial stewardship programmes, systematic CRO surveillance, and stringent infection prevention and control measures at tertiary care hospitals — particularly those managing large, heterogeneous patient populations in northern India.

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