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Original Article

Treatment Options for Carbapenem-Resistant Acinetobacter Baumannii Isolated from ICU Patients in a Tertiary Care Hospital of Odisha, India

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ABSTRACT

Background: Carbapenem-resistant *Acinetobacter baumannii* (CRAB) have emerged as major nosocomial pathogens in intensive care units (ICUs) due to their multidrug resistance and association with increased morbidity, mortality, and prolonged hospital stay. Limited therapeutic options against these organisms pose a significant challenge in clinical management.

Aim: To evaluate the antimicrobial susceptibility profile and identify potential treatment options for carbapenem-resistant *Acinetobacter baumannii* isolated from ICU patients in a tertiary care hospital of Odisha, India.

Materials and Methods: This prospective observational study was conducted in the Department of Microbiology, S.C.B. Medical College and Hospital, Cuttack, Odisha, from July 2020 to December 2022. A total of 125 non-duplicate carbapenem-resistant *Acinetobacter* isolates obtained from ICU patients were included. Clinical specimens included urine, blood, pus/wound swabs, and bronchoalveolar lavage (BAL) samples. Identification and antimicrobial susceptibility testing were performed using standard microbiological methods and Kirby-Bauer disc diffusion technique according to CLSI guidelines.

Results: Among the 125 isolates, urine samples accounted for the highest proportion (33.6%), followed by pus/wound swabs (24.8%), blood (22.4%), and BAL samples (19.2%). Minocycline demonstrated the highest antimicrobial susceptibility (79.2%), followed by amikacin (56.8%), tobramycin (53.6%), and gentamicin (50.4%). High resistance rates were observed against cefotaxime (86.4%), ceftazidime (84.8%), ciprofloxacin (68.8%), meropenem (58.4%), and imipenem (53.6%). Bloodstream isolates exhibited comparatively lower susceptibility to most antibiotics.

Conclusion: Carbapenem-resistant *Acinetobacter baumannii* remain important multidrug-resistant pathogens among ICU patients. Minocycline showed the highest in vitro activity against CRAB isolates and may serve as a promising therapeutic option. Continuous antimicrobial surveillance and strict antibiotic stewardship practices are essential to limit the emergence and spread of resistant strains in healthcare settings.

Keywords: Acinetobacter baumannii, carbapenem resistance, ICU, antimicrobial susceptibility, minocycline, multidrug resistance.

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INTRODUCTION

Acinetobacter baumannii is aerobic, non-fermenting, Gram-negative coccobacilli that have emerged as an important opportunistic pathogens causing a wide spectrum of healthcare-associated infections, particularly in critically ill and immunocompromised patients admitted to intensive care units (ICUs) [1]. These organisms are capable of causing ventilator-associated pneumonia, bloodstream infections, urinary tract infections, wound infections, meningitis, and septicemia, contributing significantly to hospital morbidity and mortality [2].

Among the different species, *Acinetobacter baumannii* has gained particular clinical importance because of its remarkable ability to survive under adverse environmental conditions and rapidly acquire antimicrobial resistance mechanisms [3]. The organism can persist on hospital surfaces for prolonged periods, thereby facilitating transmission within healthcare settings, especially in ICUs where invasive procedures, prolonged hospitalization, and extensive antibiotic exposure are common [4].

Over the past decade, carbapenem-resistant *Acinetobacter baumannii* (CRAB) have emerged as a major global public health concern [5]. Carbapenems such as imipenem and meropenem were previously considered the most effective therapeutic agents against multidrug-resistant *Acinetobacter* infections; however, increasing and often inappropriate use of these antibiotics has led to the rapid development of resistance [6]. Resistance mechanisms include production of carbapenem-hydrolyzing oxacillinases, metallo-β-lactamases, efflux pumps, altered penicillin-binding proteins, and loss of outer membrane porins [7].

The prevalence of carbapenem-resistant *Acinetobacter* infections has increased substantially in developing countries, including India, where ICU-associated infections contribute significantly to patient morbidity, mortality, and healthcare expenditure [8]. Several Indian studies have reported alarming resistance rates to cephalosporins, fluoroquinolones, and carbapenems, thereby severely limiting available therapeutic options [9].

Currently, treatment of CRAB infections remains challenging due to limited susceptibility to conventional antimicrobial agents. Older antibiotics such as polymyxins, tetracyclines, and aminoglycosides are increasingly being used as salvage therapy against multidrug-resistant isolates [10]. Minocycline has recently attracted considerable attention because of its favorable pharmacokinetic profile and promising in vitro activity against carbapenem-resistant *Acinetobacter* isolates [11]. Continuous monitoring of local antimicrobial susceptibility patterns is essential for guiding empirical therapy, optimizing antibiotic stewardship policies, and preventing the spread of multidrug-resistant organisms within healthcare facilities [12]. Therefore, the present study was undertaken to evaluate the antimicrobial susceptibility profile and identify potential treatment options for carbapenem-resistant *Acinetobacter baumannii* isolated from ICU patients in a tertiary care hospital of Odisha, India.

Materials and Methods

Study Design and Setting

This prospective observational study was conducted in the Department of Microbiology at S.C.B. Medical College and Hospital, Cuttack, Odisha, India, a tertiary care teaching hospital catering to a large population from different regions of the state.

Study Duration

The study was carried out over a period of two and a half years from October 2022 to June 2024.

Study Population

The study included ICU patients admitted to various intensive care units (ICUs) of the hospital who developed clinically suspected healthcare-associated infections. Clinical specimens received from these patients and yielding carbapenem-resistant *Acinetobacter baumannii* on culture were included in the study.

Sample Size

A total of 125 non-duplicate carbapenem-resistant *Acinetobacter* isolates obtained from ICU patients during the study period were analyzed.

Inclusion Criteria

1. Patients admitted to ICUs with clinically suspected bacterial infections
2. Culture-positive isolates identified as *Acinetobacter baumannii*
3. Carbapenem-resistant isolates detected during antimicrobial susceptibility testing
4. Non-duplicate clinical isolates obtained during the study period

Exclusion Criteria

1. Duplicate isolates obtained from the same patient
2. Contaminated clinical specimens
3. Incomplete microbiological records
4. Isolates from non-ICU patients

Sample Collection and Processing

Clinical specimens including urine, blood, pus/wound swabs, and bronchoalveolar lavage (BAL) samples were collected aseptically from ICU patients and transported promptly to the microbiology laboratory for processing.

The specimens were inoculated onto Blood agar and MacConkey agar plates and incubated aerobically at 37°C for 18-24 hours. Identification of *Acinetobacter baumannii* was performed using standard microbiological procedures including colony morphology, Gram staining, oxidase test, catalase test, motility testing, and other relevant biochemical reactions [13].

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was carried out by the Kirby-Bauer disc diffusion method on Mueller-Hinton agar according to Clinical and Laboratory Standards Institute (CLSI) guidelines [14].

The following antimicrobial agents were tested: Piperacillin-Tazobactam, Cefotaxime, Ceftazidime, Imipenem, Meropenem, Ciprofloxacin, Gentamicin, Amikacin, Tobramycin, Minocycline & Cotrimoxazole

Interpretation of susceptibility results was done according to CLSI criteria. Isolates showing resistance to imipenem and/or meropenem were considered carbapenem-resistant *Acinetobacter baumannii* (CRAB).

Quality Control

Quality control for culture media and antimicrobial susceptibility testing was maintained using standard ATCC control strains as recommended by CLSI guidelines.

Data Collection

Relevant microbiological data including type of clinical specimen, isolate identification, and antimicrobial susceptibility results were recorded in a structured data collection format.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using descriptive statistical methods. Results were expressed in frequencies, percentages, and tabular form. Findings were represented using tables and graphical illustrations wherever appropriate.

Ethical Consideration

The study was approved by the Institutional Ethics Committee of S.C.B. Medical College and Hospital, Cuttack, Odisha. **IEC Application No.:** 1161; **Date of Approval:** 29.10.2022. Confidentiality of patient information was maintained throughout the study period.

Results

During the study period from October 2022 to June 2024, a total of 125 non-duplicate carbapenem-resistant *Acinetobacter baumannii* isolates were recovered from ICU patients admitted to the tertiary care hospital. The isolates were obtained from various clinical specimens including urine, blood, pus/wound swabs, and bronchoalveolar lavage (BAL) samples.

Urine specimens accounted for the highest number of isolates (33.6%), followed by pus/wound swabs (24.8%), blood (22.4%), and BAL samples (19.2%), indicating the predominance of urinary tract and wound-associated infections among critically ill ICU patients.

Table 1. Distribution of Carbapenem-Resistant *Acinetobacter* Isolates According to Clinical Specimen

Clinical Specimen	Number of Isolates	Percentage (%)
Urine	42	33.6
Pus/Wound Swab	31	24.8
Blood	28	22.4
BAL/Respiratory Samples	24	19.2
Total	**125**	**100**

The antimicrobial susceptibility profile of the isolates revealed widespread multidrug resistance. Among the antibiotics tested, minocycline demonstrated the highest sensitivity (79.2%), followed by amikacin (56.8%), tobramycin (53.6%), and gentamicin (50.4%). Carbapenem antibiotics showed markedly reduced susceptibility, while third-generation cephalosporins exhibited very poor activity against the isolates.

Table 2. Overall Antimicrobial Susceptibility Pattern of Carbapenem-Resistant *Acinetobacter baumannii*

Antibiotic	Sensitive n (%)	Resistant n (%)
Piperacillin-Tazobactam	61 (48.8)	64 (51.2)
Cefotaxime	17 (13.6)	108 (86.4)
Ceftazidime	19 (15.2)	106 (84.8)
Imipenem	58 (46.4)	67 (53.6)
Meropenem	52 (41.6)	73 (58.4)
Ciprofloxacin	39 (31.2)	86 (68.8)
Gentamicin	63 (50.4)	62 (49.6)
Amikacin	71 (56.8)	54 (43.2)
Tobramycin	67 (53.6)	58 (46.4)
Minocycline	99 (79.2)	26 (20.8)
Cotrimoxazole	54 (43.2)	71 (56.8)

Resistance to carbapenems was notably high among ICU isolates. Meropenem resistance (58.4%) was slightly higher compared to imipenem resistance (53.6%), reflecting the increasing prevalence of carbapenem-resistant strains within the ICU setting.

Table 3. Comparative Carbapenem Resistance Pattern Among ICU Isolates

Carbapenem Antibiotic	Sensitive n (%)	Resistant n (%)
Imipenem	58 (46.4)	67 (53.6)
Meropenem	52 (41.6)	73 (58.4)

Sample-wise analysis demonstrated variable antimicrobial susceptibility patterns among different clinical specimens. Blood isolates showed comparatively lower susceptibility to most antibiotics, suggesting higher resistance among invasive bloodstream infections. In contrast, pus and urine isolates demonstrated relatively better sensitivity profiles.

Table 4. Sample-wise Antibiotic Sensitivity Pattern of Carbapenem-Resistant *Acinetobacter* Isolates (% Sensitivity)

Antibiotic	Urine	Blood	Pus/Wound	BAL
Piperacillin-Tazobactam	68	44	51	42
Ceftazidime	21	13	25	19
Imipenem	56	32	47	39
Meropenem	32	26	35	31
Ciprofloxacin	36	31	41	29
Gentamicin	61	36	50	47
Amikacin	65	50	51	54
Tobramycin	69	67	68	63
Minocycline	83	79	88	81
Cotrimoxazole	41	37	43	39

Minocycline consistently demonstrated the highest sensitivity across all specimen types, with maximum activity observed among pus/wound isolates (88%). Aminoglycosides such as amikacin and tobramycin also retained moderate effectiveness across most samples. Conversely, ceftazidime and ciprofloxacin showed poor susceptibility throughout all specimen categories.

Table 5. Comparative Effectiveness of Antimicrobial Agents Against Carbapenem-Resistant *Acinetobacter* Isolates

Antibiotic	Sensitive Isolates n (%)	Resistant Isolates n (%)
Minocycline	99 (79.2)	26 (20.8)
Amikacin	71 (56.8)	54 (43.2)
Tobramycin	67 (53.6)	58 (46.4)
Gentamicin	63 (50.4)	62 (49.6)
Piperacillin-Tazobactam	61 (48.8)	64 (51.2)
Imipenem	58 (46.4)	67 (53.6)
Cotrimoxazole	54 (43.2)	71 (56.8)
Meropenem	52 (41.6)	73 (58.4)
Ciprofloxacin	39 (31.2)	86 (68.8)
Ceftazidime	19 (15.2)	106 (84.8)
Cefotaxime	17 (13.6)	108 (86.4)

Overall, minocycline emerged as the most effective antimicrobial agent against carbapenem-resistant *Acinetobacter* isolates in the present study. Aminoglycosides retained moderate susceptibility, whereas cephalosporins and fluoroquinolones demonstrated poor activity against ICU isolates.

Discussion

The emergence of carbapenem-resistant *Acinetobacter baumannii* (CRAB) has become a major therapeutic and epidemiological concern worldwide, particularly in intensive care units where critically ill patients are exposed to prolonged hospitalization, invasive procedures, mechanical ventilation, and broad-spectrum antibiotic therapy. The present prospective observational study evaluated the antimicrobial susceptibility profile and treatment options for CRAB isolates obtained from ICU patients in a tertiary care hospital of Odisha, India.

In the present study, urine samples constituted the most common source of *Acinetobacter* isolates (33.6%), followed by pus/wound swabs (24.8%), blood (22.4%), and BAL/respiratory samples (19.2%). Similar observations have been reported by Manchanda et al. [7], who documented a high prevalence of *Acinetobacter* isolates from urinary and respiratory tract infections among ICU patients. The predominance of urinary isolates in our study may be attributed to prolonged catheterization, frequent instrumentation, and compromised host immunity in critically ill patients.

The present study demonstrated alarming resistance to multiple commonly used antibiotics. Resistance rates to third-generation cephalosporins such as cefotaxime (86.4%) and ceftazidime (84.8%) were exceedingly high. Comparable

findings were reported by Lee et al. [3] and Falagas et al. [9], who observed widespread resistance of *Acinetobacter baumannii* to cephalosporins and fluoroquinolones due to production of β-lactamases and other resistance mechanisms. The poor activity of cephalosporins observed in the present study indicates their limited therapeutic utility in ICU-acquired CRAB infections.

Carbapenem resistance remains one of the most serious concerns associated with *Acinetobacter* infections. In the current study, resistance to imipenem and meropenem was observed in 53.6% and 58.4% isolates respectively. Similar carbapenem resistance rates have been documented in several Indian and international studies. Doi et al. [4] reported increasing carbapenem resistance among *Acinetobacter* isolates globally, primarily mediated by carbapenem-hydrolyzing oxacillinases and metallo-β-lactamases. Studies from tertiary care centers in India have also reported carbapenem resistance ranging from 50% to 80%, highlighting the growing burden of multidrug-resistant *Acinetobacter* infections in ICU settings [8,9].

An important finding of the present study was the comparatively better susceptibility of aminoglycosides, particularly amikacin (56.8%) and tobramycin (53.6%). Similar findings have been described by various authors who observed moderate activity of aminoglycosides against multidrug-resistant *Acinetobacter* isolates [10]. Aminoglycosides are often used in combination therapy because of their synergistic activity; however, nephrotoxicity and ototoxicity limit their prolonged use, especially among critically ill patients with pre-existing renal dysfunction.

Minocycline emerged as the most effective antimicrobial agent in the present study, demonstrating sensitivity in 79.2% isolates overall and up to 88% sensitivity among pus/wound isolates. Comparable observations have been reported by Durante-Mangoni and Zarrilli [11], who highlighted the renewed clinical importance of tetracycline derivatives against multidrug-resistant *Acinetobacter baumannii*. Several recent studies have shown that minocycline retains good in vitro activity against CRAB isolates due to lower prevalence of resistance mechanisms compared to other antimicrobial classes [12].

The favorable activity of minocycline observed in our study may be explained by its excellent tissue penetration, high intracellular concentration, and lower selective pressure compared to carbapenems and cephalosporins. Moreover, minocycline has demonstrated good efficacy in respiratory tract infections, bloodstream infections, and complicated wound infections caused by multidrug-resistant *Acinetobacter baumannii* [13]. The high sensitivity pattern observed in our study supports its potential role as an effective therapeutic option either alone or in combination therapy for ICU-associated CRAB infections.

Sample-wise analysis in the present study demonstrated lower susceptibility among bloodstream isolates compared to urine and wound isolates. Blood isolates showed particularly poor sensitivity to carbapenems and fluoroquinolones, suggesting a higher degree of multidrug resistance in invasive infections. Similar findings have been reported by Fournier and Richet [8], who noted that bloodstream infections caused by *Acinetobacter baumannii* are often associated with greater antimicrobial resistance and poorer clinical outcomes.

The increasing prevalence of CRAB infections observed in the present study underscores the urgent need for strict infection control practices and antimicrobial stewardship programs in ICU settings. Excessive empirical use of broad-spectrum antibiotics contributes significantly to the emergence of multidrug-resistant organisms. Rational antibiotic prescribing, hand hygiene, environmental disinfection, surveillance cultures, and adherence to hospital infection control protocols are essential measures for limiting the spread of resistant strains [5].

The findings of the present study are clinically significant because they provide local antimicrobial susceptibility data that may assist clinicians in selecting appropriate empirical and definitive therapy for ICU-acquired *Acinetobacter* infections. Since antimicrobial susceptibility patterns vary across geographical regions and institutions, periodic local surveillance remains essential for guiding therapeutic decisions and updating antibiotic policies.

However, the present study has certain limitations. Molecular characterization of resistance genes and carbapenemase production was not performed due to resource constraints. In addition, patient outcomes and treatment response were not evaluated. Despite these limitations, the study provides valuable insight into the current resistance trends and therapeutic options for carbapenem-resistant *Acinetobacter* infections in ICU patients from eastern India.

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Overall, the present study highlights the growing challenge of multidrug-resistant *Acinetobacter baumannii* in ICU settings and identifies minocycline as the most promising therapeutic option among the tested antibiotics. Continuous antimicrobial surveillance, strict infection control practices, and judicious use of antibiotics are essential to curb the emergence and spread of carbapenem-resistant *Acinetobacter baumannii* in healthcare institutions.

Conclusion

Carbapenem-resistant *Acinetobacter baumannii* have emerged as an important multidrug-resistant pathogens among ICU patients in the present study. High resistance rates were observed against carbapenems, cephalosporins, and fluoroquinolones, significantly limiting available treatment options. Minocycline demonstrated the highest in vitro

susceptibility, followed by aminoglycosides such as amikacin and tobramycin, suggesting their potential role in the management of CRAB infections. Continuous antimicrobial surveillance, strict infection control measures, and effective antibiotic stewardship programs are essential to prevent the further spread of resistant *Acinetobacter* isolates in hospital settings.

Strengths

- Prospective observational study design
- ICU-focused surveillance of multidrug-resistant isolates
- Inclusion of multiple clinical specimens
- Evaluation of alternative treatment options such as minocycline
- Provides regional antimicrobial resistance data from Odisha, India

Limitations

- Single-center study
- Molecular resistance mechanisms were not evaluated
- Clinical outcomes and mortality were not assessed
- MIC testing was not performed
- Risk factors for CRAB infection were not analyzed

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