International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Multidrug-Resistant Acinetobacter baumannii in Ventilated ICU Patients: Antimicrobial Susceptibility Patterns from a Tertiary Care Hospital in Western Odisha: An Observational Study

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OPEN ACCESS

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Received: 04-01-2026
Accepted: 23-01-2026
Available online: 01-02-2026

ABSTRACT

Ventilator-associated infections caused by Acinetobacter baumannii represent a major therapeutic challenge in intensive care units (ICUs) due to the organism's remarkable capacity to develop multidrug resistance. The rising prevalence of resistant strains, particularly in mechanically ventilated patients, has significantly limited effective antimicrobial options and contributed to adverse clinical outcomes, especially in developing countries.

Materials & Methods: This cross-sectional observational study was conducted over a twelve-month period (January–December 2025) in the ICU of a tertiary care teaching hospital in Odisha, India. Endotracheal aspirates were collected aseptically from mechanically ventilated patients with clinical suspicion of ventilator-associated pneumonia. Isolates of A. baumannii were identified using standard microbiological techniques. Antimicrobial susceptibility testing was performed by the Kirby–Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute guidelines. Demographic and clinical data were recorded, and resistance patterns were analyzed using descriptive statistics and appropriate inferential tests.

Results: A. baumannii isolates demonstrated extensive resistance to multiple antibiotic classes. Complete resistance was observed to third- and fourth-generation cephalosporins and meropenem. Carbapenem resistance was notably high, with imipenem showing minimal activity. Aminoglycosides and fluoroquinolones exhibited poor efficacy, while gentamicin and cotrimoxazole showed comparatively higher, though still limited, susceptibility. The majority of isolates fulfilled criteria for multidrug resistance, underscoring the severity of antimicrobial resistance in the ICU setting. Conclusion: The study highlights an alarming burden of multidrug-resistant A. baumannii among ventilated ICU patients, with severely restricted therapeutic options.

Continuous surveillance, judicious antibiotic use, and stringent infection control practices are imperative to mitigate the spread of resistant strains and optimize patient outcomes in critical care environments.

Keywords: *Acinetobacter baumannii; Ventilator-associated pneumonia; Multidrug resistance; Intensive care unit; Antimicrobial susceptibility; Carbapenem resistance; Endotracheal aspirates; Antibiotic stewardship; Nosocomial infections; Critical care microbiology.*

INTRODUCTION

Ventilator-associated infections (VAIs), particularly ventilator-associated pneumonia (VAP), remain a major cause of morbidity and mortality among critically ill patients admitted to intensive care units (ICUs). The prolonged use of mechanical ventilation disrupts normal host defenses and facilitates colonization of the lower respiratory tract by opportunistic and often highly resistant pathogens. Among these, *Acinetobacter baumannii* has emerged as one of the most formidable nosocomial organisms, especially in resource-limited settings and developing countries [1–3]. Its remarkable ability to survive in the hospital environment, persist on inanimate surfaces, and rapidly acquire resistance determinants has contributed significantly to its global spread in ICUs.

A. baumannii is a non-fermenting, aerobic, Gram-negative coccobacillus that has gained prominence as a leading cause of ventilator-associated pneumonia, bloodstream infections, and other device-related infections [7,11]. Over the past two decades, there has been a dramatic increase in infections caused by multidrug-resistant (MDR) and carbapenem-resistant *A. baumannii* (CRAB), severely limiting therapeutic options and posing a serious public health concern [2,7,22]. The World Health Organization has categorized carbapenem-resistant *A. baumannii* as a "critical priority pathogen," emphasizing the urgent need for surveillance and development of new treatment strategies [30].

The antimicrobial resistance profile of *A. baumannii* varies widely across geographical regions and healthcare settings, largely influenced by antibiotic usage patterns and infection control practices. Indian ICUs, in particular, have reported alarmingly high resistance rates to commonly used antibiotics, including cephalosporins, fluoroquinolones, aminoglycosides, and carbapenems [2,4,5,12,19]. Resistance mechanisms in *A. baumannii* are multifactorial and include production of extended-spectrum β-lactamases (ESBLs), AmpC β-lactamases, carbapenem-hydrolyzing OXA-type enzymes, target-site mutations, efflux pump overexpression, and loss of outer membrane porins [10,15,20,21]. These mechanisms not only confer resistance to multiple antibiotic classes but also facilitate rapid dissemination of resistance within hospital environments.

Although several studies from India and abroad have documented the resistance patterns of *A. baumannii*, continuous and region-specific surveillance remains essential due to the organism's dynamic resistance profile and evolving epidemiology [1,5,16,19]. Endotracheal aspirates from mechanically ventilated patients serve as a reliable specimen for monitoring lower respiratory tract colonization and infection, providing valuable insights into local antimicrobial susceptibility trends. Such data are critical for guiding empirical therapy, optimizing antibiotic stewardship programs, and reducing adverse clinical outcomes associated with inappropriate antibiotic use.

Despite advances in critical care medicine, the management of *A. baumannii* infections remains challenging due to limited effective antimicrobial options and increasing resistance even to last-resort drugs. Understanding local susceptibility patterns is therefore indispensable for clinicians and microbiologists alike, particularly in high-risk settings such as ICUs. Moreover, documenting resistance trends contributes to the broader understanding of the global burden of MDR pathogens and supports the formulation of evidence-based infection control policies [11,22,30]. The present study was undertaken to analyze the antimicrobial susceptibility pattern of *Acinetobacter baumannii* isolated from endotracheal aspirates of ventilated ICU patients in a tertiary care hospital. The study aims to assess the extent of multidrug resistance among these isolates and to compare the observed resistance patterns with those reported in Indian and international literature, thereby providing data to support rational antibiotic use and effective infection control strategies.

MATERIALS & METHODS

This cross-sectional observational study was conducted jointly by the Department of Microbiology, Hi-Tech Medical College & Hospital, Rourkela, in collaboration with the Intensive Care Unit (ICU) of a tertiary-care teaching hospital in Odisha, India. The study was carried out over a twelve-month period from January 2025 to December 2025. The investigation focused on mechanically ventilated ICU patients with suspected ventilator-associated pneumonia (VAP), a population known to be at high risk for multidrug-resistant *Acinetobacter baumannii* infections [2,7,30].

Adult patients admitted to the ICU and receiving mechanical ventilation for more than 48 hours were eligible for inclusion. Patients were enrolled if they met clinical criteria suggestive of VAP, including purulent endotracheal secretions, fever, leukocytosis or leukopenia, and new or progressive pulmonary infiltrates on chest radiography. Patients with prolonged ICU stay and prior antibiotic exposure were included, reflecting real-world ICU practice and antimicrobial selection pressure [1,5]. Patients with duplicate isolates were excluded to avoid data redundancy.

Ethical Considerations

Written informed consent was obtained from the patient's legally authorized representative prior to enrolment. The study protocol adhered to the ethical principles outlined in the Declaration of Helsinki and national biomedical research guidelines. All patient identifiers were anonymized to ensure confidentiality [16].

Sample Collection and Processing

Endotracheal aspirates were collected aseptically from patients with suspected VAP using sterile suction catheters following standardized infection-control protocols. Approximately 2–3 mL of aspirate was obtained and transported immediately to the microbiology laboratory in sterile containers. Samples not processed within one hour were stored at 4°C and cultured within four hours to preserve bacterial viability.

Microbiological Identification

Specimens were subjected to Gram staining to assess bacterial morphology and inflammatory cell response. Samples were cultured on MacConkey agar and 5% sheep blood agar and incubated aerobically at 37°C for 24–48 hours. Isolates showing characteristic non-lactose-fermenting colonies were further identified using standard biochemical tests, including oxidase, catalase, citrate utilization, and motility testing. *Acinetobacter baumannii* was identified as a non-motile, oxidase-negative, Gram-negative coccobacillus in accordance with established microbiological criteria [7,11].

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar (HiMedia, India), following Clinical and Laboratory Standards Institute (CLSI) guidelines [17]. The antibiotics tested included amikacin, ampicillin–sulbactam, cefepime, ceftriaxone, ciprofloxacin, gentamicin, imipenem, levofloxacin, meropenem, and piperacillin–tazobactam. Quality control was ensured using *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853. Multidrug resistance (MDR) was defined as resistance to at least one antimicrobial agent in three or more antibiotic classes, consistent with internationally accepted definitions [2,22].

Quality Control and Biosafety

All laboratory procedures were conducted under Biosafety Level-2 (BSL-2) conditions. Standard operating procedures were followed for specimen handling, processing, and disposal in compliance with Biomedical Waste Management Rules, Government of India (2018). Internal quality assurance measures included routine calibration of laboratory equipment and periodic review of testing protocols.

STATISTICAL ANALYSIS

Data were entered into Microsoft Excel and analyzed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize patient characteristics and resistance patterns. Categorical variables were expressed as proportions and percentages. Where applicable, chi-square tests and logistic regression analyses were used to assess associations between clinical variables and resistance patterns. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: The antibiotic sensitivity pattern of Acinetobacter baumannii observed in endotracheal aspirates from ventilated ICU patients (n = 100).

Antibiotics	Number of Antibiotics tested	Number of Antibiotics found sensitive
Amikacin	89	2
Ampicillin Sulbactam	83	2
Cefepime	73	0
Ceftriaxone	91	0
Ciprofloxacin	85	2
Gentamicin	79	15
Imipenem	91	3
Levofloxacin	91	5
Meropenem	91	0
Piperacillin Tazobactam	91	7
Cotrimoxazole	91	11

A total of 100 endotracheal aspirate samples from ventilated ICU patients were analyzed for the antibiotic sensitivity pattern of *Acinetobacter baumannii*. The organism demonstrated a high level of antimicrobial resistance across most of the antibiotics tested. Among 89 isolates tested for Amikacin, only 2 (2.2%) were found to be sensitive. Similarly, Ampicillin–Sulbactam showed sensitivity in only 2 out of 83 isolates (2.4%). Complete resistance was observed against Cefepime (0/73), Ceftriaxone (0/91), and Meropenem (0/91), indicating total lack of susceptibility to these antibiotics.

Fluoroquinolones showed very limited effectiveness, with Ciprofloxacin sensitivity observed in 2 out of 85 isolates (2.4%) and Levofloxacin in 5 out of 91 isolates (5.5%). Aminoglycoside Gentamicin demonstrated comparatively better activity, with 15 out of 79 isolates (19.0%) showing sensitivity. Imipenem, a carbapenem antibiotic, was effective in only

3 out of 91 isolates (3.3%), reflecting a high degree of carbapenem resistance. Piperacillin–Tazobactam showed sensitivity in 7 out of 91 isolates (7.7%), while Cotrimoxazole exhibited sensitivity in 11 out of 91 isolates (12.1%).
Overall, the observations indicate that *Acinetobacter baumannii* isolates from ventilated ICU patients were predominantly multidrug-resistant, with Gentamicin and Cotrimoxazole showing relatively higher, though still limited, sensitivity compared to other antibiotics tested

DISCUSSION

Ventilator-associated infections caused by *Acinetobacter baumannii* have emerged as a major challenge in intensive care units (ICUs), particularly in developing countries, owing to the organism's remarkable ability to acquire multidrug resistance (MDR). In the present study, *A. baumannii* isolates obtained from endotracheal aspirates of ventilated ICU patients demonstrated an alarmingly high level of resistance to multiple classes of antibiotics, underscoring the critical therapeutic dilemma posed by this pathogen.

The observed low sensitivity to aminoglycosides, particularly Amikacin (2.2%), is consistent with several Indian studies that have reported declining susceptibility of *A. baumannii* to aminoglycosides due to widespread empirical use and selective pressure in ICU settings [1–3]. Similar low sensitivity rates to Amikacin (3–10%) have been documented from tertiary care hospitals across India, including studies [4,5]. International studies from Southeast Asia and the Middle East have also reported comparable resistance trends, attributing this to aminoglycoside-modifying enzymes and efflux pump overexpression [6,7].

Ampicillin–Sulbactam, which has traditionally been considered a therapeutic option for *Acinetobacter* infections, showed poor activity in the present study (2.4%). This finding aligns with recent Indian reports showing sensitivity rates below 10% [8,9]. In contrast, earlier studies from Europe and the United States had reported moderate susceptibility (30–50%), highlighting a temporal and geographical shift in resistance patterns [10,11]. The near-universal resistance observed in the current study likely reflects prolonged and unregulated use of β-lactam/β-lactamase inhibitor combinations in Indian ICUs.

Complete resistance to third- and fourth-generation cephalosporins (Ceftriaxone and Cefepime) observed in this study mirrors findings from both Indian and global literature [12–14]. Cephalosporin resistance in *A. baumannii* is largely mediated by the production of extended-spectrum β-lactamases (ESBLs) and AmpC β-lactamases, rendering these agents clinically ineffective [15]. Studies from China, Iran, and Turkey have reported resistance rates exceeding 90%, comparable to the 100% resistance noted in the present study [16–18].

Carbapenem resistance represents one of the most concerning findings of this study. Both Imipenem and Meropenem showed extremely low to absent sensitivity, with Meropenem demonstrating complete resistance. Similar high carbapenem resistance rates have been reported from Indian ICUs, ranging from 80% to 100% [3,19]. The emergence of carbapenem-resistant *A. baumannii* (CRAB) has been attributed to the production of carbapenem-hydrolyzing oxacillinases (OXA-type enzymes), particularly OXA-23, OXA-24, and OXA-58 [20,21]. International surveillance studies, including those from Europe and Latin America, have also reported an alarming rise in CRAB isolates, confirming the global nature of this threat [22,23].

Fluoroquinolones demonstrated minimal activity in the present study, with Ciprofloxacin and Levofloxacin sensitivities of 2.4% and 5.5%, respectively. These findings are in concordance with Indian studies reporting fluoroquinolone resistance rates exceeding 90% [5,9]. Similar resistance patterns have been documented in studies from South Korea and Spain, where target site mutations in DNA gyrase and topoisomerase IV have been implicated [24,25]. The extensive use of fluoroquinolones for both community- and hospital-acquired infections may have contributed significantly to this resistance.

Among the antibiotics tested, Gentamicin showed comparatively higher sensitivity (19%), though this remains clinically suboptimal. Comparable sensitivity rates (15–25%) have been reported in Indian studies, suggesting partial retention of activity against certain isolates [1,4]. Cotrimoxazole also demonstrated limited effectiveness (12.1%), a finding consistent with studies from India and Southeast Asia reporting sensitivity rates between 10% and 30% [26,27]. While these agents may offer limited therapeutic options, their use should be guided strictly by susceptibility testing due to the narrow margin of effectiveness.

Piperacillin–Tazobactam exhibited low sensitivity (7.7%) in the present study, aligning with Indian and foreign studies that report diminishing efficacy of this combination against *A. baumannii* [8,28]. Resistance mechanisms such as β-lactamase production and porin loss have been implicated in reduced susceptibility [29].

Overall, the findings of the present study highlight a predominance of multidrug-resistant *A. baumannii* isolates in ventilated ICU patients, with resistance spanning β-lactams, carbapenems, fluoroquinolones, and aminoglycosides. Similar resistance profiles have been widely reported across Indian ICUs, emphasizing the urgent need for stringent antibiotic stewardship, regular surveillance of resistance patterns, and adherence to infection control practices [2,19,30]. The limited susceptibility observed with Gentamicin and Cotrimoxazole suggests that these agents may still have a restricted role in combination therapy, though emerging resistance warrants cautious use.

CONCLUSION

In conclusion, the resistance pattern observed in this study is reflective of a broader national and global trend of escalating antimicrobial resistance in *A. baumannii*. Continuous monitoring, judicious antibiotic use, and exploration of alternative therapeutic strategies, including combination regimens and novel antimicrobial agents, are imperative to curb the spread of this formidable nosocomial pathogen.

DECLARATION

Conflicts of interests: The authors declare no conflicts of interest.
Author contribution: All authors have contributed in the manuscript.
Author funding: Nill

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