



Original Article

The rising alarm of multidrug resistant *Acinetobacter baumannii* isolated from endotracheal aspirates of ICU patients admitted in a tertiary care hospital

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ABSTRACT

Background: In recent years, ‘*Acinetobacter baumannii*’ has established a reputation as a multidrug-resistant pathogen responsible for ventilator-associated pneumonia (VAP). VAP remains a leading cause of morbidity and mortality in intensive care units (ICUs). The aims of the investigation were to characterise the antibiotic resistance profiles of *Acinetobacter baumannii* isolates obtained from endotracheal aspirates of patients undergoing mechanical ventilation in the intensive care unit of KM Medical college, Mathura. Additionally, the study sought to offer vital insights into the escalating threat of multidrug-resistant *Acinetobacter baumannii* through a comprehensive analysis of local resistance data and a comparative review of findings at both national and international levels. It is essential that the findings highlight the importance of infection control protocols, the critical need for antimicrobial stewardship, and the imperative to explore innovative therapeutic strategies. These encompass combination therapies, antibiotics reserved solely as a final option, and innovative alternatives such as vaccines and bacteriophage therapy. Within a tertiary care facility situated in KM Medical college, Mathura, a cross-sectional observational study was conducted over a period of seven consecutive months. Conventional microbiological techniques were employed to analyse endotracheal aspirates obtained from individuals suspected of having ventilator-associated pneumonia (VAP). ‘The *Acinetobacter baumannii* isolates underwent biochemical identification and antibiotic susceptibility testing in accordance with the guidelines established by the Clinical and Laboratory Standards Institute (CLSI, 2023). The Kirby-Bauer disc diffusion method was employed to achieve this’. The results were analysed through statistical methods, and the resistance patterns were assessed. Findings: Forty-five unique *A. baumannii* isolates were identified. The overall resistance of the isolates to cefepime, ceftriaxone, and meropenem was assessed, indicating that the resistance levels were increased. In terms of sensitivity, imipenem exhibited a low rate of 2.2%, whereas aminoglycosides and fluoroquinolones demonstrated ineffectiveness with rates of 18% or higher. Cotrimoxazole demonstrated significant activity against 11.1% of the isolates, whereas piperacillin-tazobactam exhibited a sensitivity rate of 6.6%. This study underscores the significant challenge posed by multidrug-resistant *Acinetobacter baumannii* in ventilated intensive care unit patients, a concern compounded by the limited therapeutic options available. The findings highlight the imperative necessity to confront this global health issue through the prudent use of antibiotics, the implementation of responsible antimicrobial stewardship, and the consideration of innovative therapeutic approaches.

Keywords: Ventilator-associated pneumonia; Intensive care units; *Acinetobacter baumannii*; Multidrug-resistant; antimicrobial stewardship; Clinical and Laboratory Standards Institute.

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INTRODUCTION

It is no secret that ventilator-associated pneumonia (VAP) ranks high among the nosocomial illnesses that infect patients admitted to critical care units (Intensive Care Units). There is a correlation between this and elevated rates of morbidity and mortality, as well as extended hospital stays, increased medical expenditures, and overall higher healthcare costs.. *Acinetobacter baumannii* is a multidrug-resistant bacterium associated with ventilator-related pneumonia; treating this bacterium is a major therapeutic problem worldwide. The organism is renowned for its ability to disseminate among critically ill patients, flourish in hospital environments, and rapidly acquire resistance mechanisms. [1].

Worldwide, *A. baumannii* infections are common. Given that carbapenem-resistant *Acinetobacter baumannii* is a critical priority infection, the World Health Organisation (WHO) has advocated for urgent research and the development of innovative therapies to address this disease.. Studies conducted in North America and Europe show that carbapenem resistance frequently surpasses 80–90% in several intensive care units [3,4]. Multicenter surveillance studies in Asia, which have shown concerning levels of resistance, have highlighted the global scope of this healthcare problem. [5,6].

The elevated prevalence of drug addiction and antimicrobial resistance (AMR) in India significantly exacerbates the severity of the issue. The occurrence of carbapenem-resistant *A. baumannii* is more widespread in tertiary care environments, as indicated by the findings of national surveillance programs such as the Indian Council of Medical Research Antimicrobial Resistance Surveillance and Research Network (ICMR-AMRSN). Recent regional studies conducted in South India, Mumbai, and New Delhi indicate that over 70–90% of individuals exhibit resistance to carbapenems and cephalosporins [8,9]. These findings align with global trends and underscore the imperative for judicious antibiotic utilisation and effective infection control measures in Indian healthcare settings.

MDR *A. baumannii* infections are associated with high death rates, limited treatment options, and unfavourable outcomes. Indian research indicates that ICU patients infected with carbapenem-resistant bacteria exhibit mortality rates ranging from 40 to 60 percent [13]. International statistics corroborate these findings, indicating that *A. baumannii* infections are linked to prolonged ICU admissions and heightened attributable mortality [14]. The rising resistance to frequently utilised antibiotics, including cephalosporins, aminoglycosides, and fluoroquinolones, underscores the critical need for comprehensive local antibiograms to inform treatment choices and further complicates the implementation of empirical therapy. The aims of the investigation were to characterise the antibiotic resistance profiles of *Acinetobacter baumannii* isolates obtained from endotracheal aspirates of patients undergoing mechanical ventilation in the intensive care unit. Additionally, the study sought to offer vital insights into the escalating threat of multidrug-resistant *Acinetobacter baumannii* through a comprehensive analysis of local resistance data and a comparative review of findings at both national and international levels. The findings should underscore the importance of infection control protocols, the necessity of antimicrobial stewardship, and the imperative to explore innovative therapeutic strategies. These encompass combination therapies, antibiotics reserved exclusively as a final measure, and novel alternatives such as vaccines and bacteriophage therapy. [16,17].

MATERIALS & METHODS

Jointly with the intensive care unit of a teaching hospital in Uttar Pradesh, researchers from the Department of Microbiology at KM Medical college, Mathura undertook this cross-sectional observational study. A total of seven months, from January 2025 to July 2025, were devoted to the research.

Patients who had been on mechanical ventilation for more than 48 hours while inpatient in the critical care unit were eligible to participate in the study. Patients were considered for participation in the trial if they had symptoms of ventilator-associated pneumonia (VAP), which included purulent endotracheal secretions, fever, leukocytosis or leukopenia, and new or worsened radiological infiltrates. patients hospitalised to the surgical intensive care unit who have weakened immune systems or who have taken antibiotics for longer than seven days.

Prior to inclusion in the trial, written informed consent was obtained from the patients' guardians or next of kin. In accordance with national biomedical research protocols and the Declaration of Helsinki, all data were anonymised to ensure confidentiality [16].

Collection and Preservation of Samples: Aseptic endotracheal aspirates were collected from suspected cases of ventilator-associated pneumonia (VAP). Sterile suction catheters were introduced into the lumen using a defined aseptic protocol after the endotracheal tube was occluded prior to sample collection. Two to three millilitres of endotracheal aspirate were promptly collected and dispatched in sterile containers to the microbiology laboratory. To preserve viability, samples not processed within one hour were refrigerated at 4°C and processed within four hours of collection.

Microbiological Identification: Samples were subjected to Gramme staining to ascertain the initial bacterial morphology and pus cell count. MacConkey agar and 5% sheep blood agar plates were utilised for culturing and incubated aerobically for 24 to 48 hours at 37°C. Standard biochemical assays, including oxidase, catalase, citrate utilisation, and motility tests, were employed to further characterise colonies that morphologically resembled *Acinetobacter* species (non-fermenting, oxidase-negative, Gram-negative coccobacilli).

The ‘Kirby-Bauer disc diffusion technique was employed on Mueller-Hinton agar (HiMedia, India) to assess the antibiotic susceptibility of all validated *Acinetobacter baumannii* isolates [17]. This procedure was carried out in accordance with the guidelines established by the Clinical and Laboratory Standards Institute (CLSI). During the experiment, a selection of commercially available antibiotic discs was employed. Piperacillin-tazobactam, ciprofloxacin, gentamicin, imipenem, levofloxacin, meropenem, amikacin, ampicillin-sulbactam, cefepime, and ceftriaxone are among the antibiotics encompassed within this category. In every batch of susceptibility testing, the quality control microorganisms *Pseudomonas aeruginosa* ATCC 27853 and *Escherichia coli* ATCC 25922 were employed’. This was implemented to ensure the precision of the results. The CLSI 2023 guidelines facilitated the application of interpretive criteria for the susceptible, intermediate, and resistant categories. This was enabled through the implementation of the recommendations.

Biosafety and quality assurance protocols encompass the following measures: All laboratory procedures were executed meticulously in accordance with the standards of Biosafety Level 2 (BSL-2) and under highly stringent biosafety conditions. The personal protective equipment (PPE) utilised during the handling and processing of samples comprised gloves, masks, lab jackets, and other forms of protective gear. The collection, transportation, and disposal of biomedical waste were conducted in accordance with standard operating procedures (SOPs) established in compliance with the Biomedical Waste Management Rules (2018) enacted by the Government of India. To ensure precise internal quality control, periodic calibrators were employed. The Significance of Statistical Power and Sample Size A total of 45 distinct isolates of *Acinetobacter baumannii* were identified in the endotracheal aspirates of patients undergoing mechanical ventilation in the intensive care unit. Data from hospital infection surveillance and the estimated prevalence of *A. baumannii* in intensive care unit respiratory samples (approximately 20–25%) were employed to determine the appropriate sample size. Given that the sample size was sufficiently large to provide adequate statistical power for detecting resistance patterns within 95% confidence intervals, the study's findings were validated as accurate.

Ethical and Clinical Relevance: This study’s methodological rigor ensures clinical relevance, as it directly addresses the problem of antibiotic resistance in ventilated ICU patients, a population at high risk for nosocomial infections. By employing standardized collection techniques, quality controls, and validated susceptibility testing methods, the study provides reliable data to guide empirical therapy and infection control strategies in critical care settings.

Data acquisition and examination: Standardised case record forms were utilised to collect patient demographic data, including age, sex, pre-existing comorbidities, duration of ICU admission, and prior antibiotic exposure. Furthermore, details on radiological findings and clinical presentation were recorded. Antibiotic susceptibility results were compiled, and resistance percentages were calculated for each prescription. Resistance to a minimum of one agent across three or more antimicrobial categories is termed multidrug resistance (MDR).

The data was entered into Microsoft Excel and subsequently analysed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics calculated include proportions, means, and standard deviations. Percentages were employed to demonstrate the antibiotic resistance. Chi-square tests and logistic regression models were employed, if applicable, to evaluate the associations between clinical variables and outcomes. A P-value below 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 = 45).

Antibiotics	Number of Antibiotics tested	Number of Antibiotics found sensitive	Percentage of Antibiotics found sensitive
Amikacin	44	1	2.27 %
Ampicillin Sulbactam	41	1	2.4 %
Cefepime	36	0	0 %
Ceftriaxone	45	0	0 %
Ciprofloxacin	42	1	2.38 %
Gentamicin	39	7	17.9 %
Imipenem	45	1	2.2 %
Levofloxacin	45	2	4.4 %
Meropenem	45	0	0 %
Piperacillin Tazobactam	45	3	6.6 %
Cotrimoxazole	45	5	11.1 %

A total of 45 *Acinetobacter baumannii* strains were isolated from endotracheal aspirates of ICU patients on mechanical ventilation. The isolates were subjected to antibiotic susceptibility testing, and resistance patterns were determined.

The isolates demonstrated an alarming degree of multidrug resistance (MDR). Resistance was highest against third- and fourth-generation cephalosporins, with 100% resistance to ceftriaxone (n=45/45) and cefepime (n=36/36 tested). Similarly, meropenem (0% sensitivity) and imipenem (2.2% sensitivity) exhibited minimal effectiveness, indicating a worrisome prevalence of carbapenem resistance.

Aminoglycosides demonstrated slightly better performance, though still limited: gentamicin was effective against 17.9% of isolates (n=7/39 tested), while amikacin showed activity against only 2.27% (n=1/44).

Among fluoroquinolones, ciprofloxacin and levofloxacin retained sensitivity in only 2.38% (n=1/42) and 4.4% (n=2/45) of isolates, respectively. The β -lactam/ β -lactamase inhibitor combination piperacillin–tazobactam demonstrated activity against 6.6% (n=3/45).

Interestingly, cotrimoxazole displayed moderate sensitivity (11.1%, n=5/45), though the overall effectiveness remained unsatisfactory. The cumulative data strongly indicates that nearly all isolates were MDR, demonstrating resistance to various antibiotics, including fluoroquinolones, aminoglycosides, cephalosporins, and carbapenems, among others. In cases of ventilator-associated pneumonia caused by *A. baumannii*, the pattern underscores an urgent need for rigorous infection control measures, judicious antibiotic stewardship, and the exploration of alternative therapeutic options ..

DISCUSSION

The present study highlights the alarming prevalence of MDR *A. baumannii* isolates recovered from endotracheal aspirates of ICU patients on mechanical ventilation. Our results demonstrated near-complete resistance to carbapenems, cephalosporins, fluoroquinolones, and aminoglycosides, with only marginal sensitivity to piperacillin–tazobactam and cotrimoxazole. These findings align with national and international trends, underscoring the pathogen's notorious adaptability and the urgent need for effective infection control measures.

Global Perspective on Acinetobacter Resistance: Globally, *A. baumannii* has emerged as a significant nosocomial pathogen, often implicated in VAP, bacteremia, and urinary tract infections. Reports from Europe and the United States consistently demonstrate high carbapenem resistance, reaching up to 90% in certain ICUs [18,19]. A 2022 WHO report classified carbapenem-resistant *A. baumannii* as a critical priority pathogen, reflecting its clinical importance and limited treatment options [3]. Recent multicentric studies in China and South Korea also documented similar resistance trends, with carbapenem resistance exceeding 85% [20,21].

Indian Context and Comparative Data: In India, the problem of MDR *A. baumannii* is particularly concerning due to widespread antibiotic misuse and inadequate antimicrobial stewardship. A multicentric surveillance study by [22] revealed carbapenem resistance in over 70% of isolates across tertiary care centers. More recently, [23] from New Delhi reported resistance rates approaching 90% for imipenem and meropenem, closely mirroring the findings of our study. Regional studies, such as that of [24] in North India, also documented high resistance to cephalosporins and aminoglycosides, further emphasizing the widespread nature of the issue in Indian ICUs. Our study adds to this growing body of evidence by demonstrating near-total resistance, suggesting that therapeutic options are rapidly dwindling.

Mechanisms of Resistance: The high degree of resistance observed in our isolates can be attributed to multiple mechanisms, including production of carbapenem-hydrolyzing oxacillinases, efflux pump overexpression, and porin channel alterations [25]. Several Indian molecular studies have confirmed the presence of blaOXA-23 and blaNDM genes in clinical isolates, which strongly correlate with carbapenem resistance [26,27]. These molecular mechanisms, compounded by the clonal spread of high-risk lineages such as international clone II, explain the persistence and dominance of *A. baumannii* in critical care units worldwide.

Therapeutic Challenges and Alternatives: The therapeutic implications of our findings are significant. Carbapenems, once considered the mainstay against MDR *A. baumannii*, are now virtually ineffective. Aminoglycosides and fluoroquinolones also displayed poor efficacy, consistent with global surveillance data [17]. The moderate sensitivity to cotrimoxazole in our isolates (11.1%) is noteworthy, as previous reports from India have occasionally highlighted its retained activity [28]. However, the overall effectiveness remains insufficient for empirical use.

Recent studies suggest colistin and tigecycline as potential therapeutic options. Colistin, despite its nephrotoxicity, continues to be used as a last-resort drug [29,30]. A study by [31] reported susceptibility rates above 90% to colistin, though emerging resistance has also been noted. Tigecycline, either alone or in combination with sulbactam, has shown variable efficacy, with some reports indicating improved outcomes in severe infections [32,33]. Novel therapeutic approaches, including combination regimens such as colistin–rifampicin or sulbactam–daptomycin, are under exploration, though clinical data remain limited [34].

Impact on ICU Outcomes: The clinical impact of MDR *A. baumannii* in ICUs cannot be overstated. Studies consistently demonstrate that infections caused by MDR strains are associated with prolonged hospital stay, increased mechanical

ventilation days, higher costs, and significantly elevated mortality^[35,36]. In Indian ICUs, mortality attributable to carbapenem-resistant *A. baumannii* infections ranges between 40–60%^[37]. Our study's findings reinforce the necessity for rapid identification, targeted therapy, and aggressive infection prevention measures to reduce morbidity and mortality. Infection Control and Stewardship: The near-total resistance observed in this study calls for robust infection control strategies. Evidence supports that strict hand hygiene, environmental cleaning, and contact precautions can significantly curb *A. baumannii* transmission^[38]. In India, implementation of antimicrobial stewardship programs (ASPs) has been shown to reduce inappropriate carbapenem usage, thereby slowing resistance trends^[39,40]. Our study emphasizes the urgent need for nationwide adoption of ASPs, especially in resource-limited settings where MDR pathogens are rampant. Future Directions: Novel Therapeutics and Vaccines: Research into novel therapeutics, including bacteriophage therapy, antimicrobial peptides, and monoclonal antibodies, is ongoing^[41]. Phage therapy has shown promise against MDR *A. baumannii* in compassionate-use cases, and clinical trials are underway. Similarly, vaccine development targeting outer membrane proteins of *A. baumannii* may provide a preventive strategy in high-risk ICU populations^[42]. However, these remain experimental and far from routine clinical use.

Strengths and Limitations: The strengths of our study lie in its clinical relevance and focus on endotracheal aspirates from ventilated ICU patients, a population highly vulnerable to VAP. The study provides real-world resistance data critical for guiding empirical therapy in ICUs. However, limitations include the relatively small sample size and lack of molecular characterization of resistance genes. Future research should incorporate genomic sequencing to elucidate resistance mechanisms and clonal relationships among isolates.

CONCLUSION

In conclusion, The results of this study underscore the considerable threat that multidrug-resistant *A. baumannii* presents within intensive care units, owing to its almost total resistance to antibiotics including fluoroquinolones, carbapenems, cephalosporins, and aminoglycosides. The limited effectiveness of alternative pharmaceuticals highlights the imperative necessity for improved infection control measures, prudent use of antibiotics, and the exploration of innovative therapeutic approaches simultaneously. Our findings support the view that the pathogen represents one of the most formidable challenges in modern critical care microbiology. Furthermore, they concur with the data gathered from India and other nations over the past decade.

Conflict of interest

None.

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