e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(9); 175-178

Original Research Article

Detection of Carbapenem-Resistant Pseudomonas aeruginosa in Ventilator-Associated Pneumonia and Its Impact on Clinical Outcomes

Savan Kantibhai Patel[1], Shivang Kishorkumar Brahmbhatt[2], Dhruti Laxmikant Thacker[3]

[1,3]MBBS, GMERS Medical College, Himmatnagar, Gujarat, India
[2]G.D.M.O., Department of Medical Services, ONGC, Ahmedabad, Gujarat, India

Received: 01-08-2025 / Revised: 03-09-2025 / Accepted: 08-09-2025
Corresponding author: Dr. Dhruti Laxmikant Thacker
Conflict of interest: Nil

Abstract

Background: Carbapenem-resistant Pseudomonas aeruginosa (CRPA) is an emerging multidrug-resistant pathogen in intensive care units (ICUs), particularly in cases of ventilator-associated pneumonia (VAP). Its resistance limits therapeutic options and is linked to poor clinical outcomes, including prolonged hospital stays and increased mortality. This study aimed to detect CRPA in VAP patients and evaluate its impact on clinical outcomes in a tertiary care hospital.

Materials and Methods: A prospective observational study was conducted over 12 months in the ICU of a tertiary care teaching hospital. Adult patients (≥18 years) meeting the Centers for Disease Control and Prevention (CDC) diagnostic criteria for VAP and with culture-confirmed Pseudomonas aeruginosa were included. Endotracheal aspirates and bronchoalveolar lavage specimens were collected under aseptic precautions and processed using standard microbiological techniques. Carbapenem resistance was determined by disc diffusion and confirmed by minimum inhibitory concentration (MIC) testing as per CLSI guidelines. Demographic data, comorbidities, treatment regimens, length of ICU stay, and patient outcomes were recorded. Statistical analysis was performed using SPSS v26.0, with p-values <0.05 considered significant.

Results: A total of 96 patients with culture-confirmed P. aeruginosa VAP were included. The prevalence of carbapenem resistance was 38.5% (n = 37). Patients with CRPA had a significantly longer mean ICU stay (18.4 ± 5.3 days) compared to those with carbapenem-sensitive isolates (12.6 ± 4.1 days, p<0.001). The overall mortality rate was 39.5% in the CRPA group versus 18.6% in the sensitive group (p=0.021). Multivariate analysis identified CRPA infection, presence of septic shock, and higher APACHE II scores as independent predictors of mortality (p<0.05).

Conclusion: CRPA is a significant pathogen in VAP, associated with prolonged ICU stay and higher mortality. Early detection, strict infection control measures, and judicious antibiotic stewardship are essential to limit its spread and improve patient outcomes.

Keywords: Ventilator-Associated Pneumonia, Pseudomonas Aeruginosa, Carbapenem Resistance, Intensive Care Unit, Mortality, Clinical Outcomes.

Introduction

Ventilator-associated pneumonia (VAP) is one of the most common hospital-acquired infections in intensive care units (ICUs), typically developing after 48 hours of mechanical ventilation [1]. It is associated with increased morbidity, prolonged ICU stays, higher healthcare costs, and substantial mortality [2,3]. Among the bacterial pathogens implicated in VAP, Pseudomonas aeruginosa is particularly concerning due to its intrinsic resistance to multiple antibiotics and its ability to acquire new resistance mechanisms [4,5]. In recent years, the emergence of carbapenem-resistant Pseudomonas aeruginosa (CRPA) has posed a serious therapeutic challenge. Carbapenems, such as imipenem and meropenem, are often used as last-line agents for treating multidrug-resistant Gram-negative infections [6]. Resistance to these agents in P. aeruginosa can result from multiple mechanisms, including production of carbapenem-hydrolyzing enzymes, efflux pump overexpression, and porin channel alterations [7,8]. The prevalence of CRPA varies widely across regions, with higher rates reported from ICUs in developing countries due to limited antimicrobial stewardship, high antibiotic pressure, and lapses in infection control practices [9]. Infections caused by CRPA are associated with limited therapeutic options, often necessitating the use of polymyxins, aminoglyco

sides, or combination regimens, which may be less effective and more toxic. Clinical outcomes of VAP due to CRPA are generally poorer than those caused by susceptible strains, with studies reporting higher rates of treatment failure, longer ICU stays, and increased mortality. Early detection of carbapenem resistance, along with targeted antimicrobial therapy and stringent infection control, is therefore critical to reducing adverse outcomes.

The present study was undertaken to determine the prevalence of CRPA in patients with VAP in a tertiary care ICU and to assess its impact on key clinical outcomes, including ICU length of stay and mortality.

Materials and Methods

Study Design and Setting: A prospective observational study was conducted in the adult intensive care unit (ICU) of a tertiary care teaching hospital over a 12-month period (January–December 2024).

Study Population: The study included all mechanically ventilated adult patients (≥18 years) who developed ventilator-associated pneumonia (VAP) and had culture-confirmed Pseudomonas aeruginosa isolated from respiratory specimens.

Inclusion Criteria

- Patients fulfilling the Centers for Disease Control and Prevention (CDC) diagnostic criteria for VAP
- Growth of Pseudomonas aeruginosa in endotracheal aspirate (ETA) or bronchoalveolar lavage (BAL) cultures
- Availability of complete clinical and microbiological data

Exclusion Criteria

- Patients with pneumonia prior to initiation of mechanical ventilation
- Polymicrobial cultures where P. aeruginosa was not the predominant pathogen
- Repeat isolates from the same patient during the same VAP episode

Sample Collection and Processing: Endotracheal aspirates or bronchoalveolar lavage specimens were collected under aseptic precautions. Quantitative culture methods were used, and isolates were identified as Pseudomonas aeruginosa using standard biochemical tests and confirmed with an automated identification system (e.g., VITEK 2).

Antimicrobial Susceptibility Testing: Initial screening for carbapenem resistance was performed using the Kirby–Bauer disc diffusion method with imipenem (10 µg) and meropenem (10 µg) discs. Minimum inhibitory concentrations (MICs) were determined by broth microdilution, and results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) 2024 guidelines. Isolates resistant to either imipenem or meropenem were classified as carbapenem-resistant Pseudomonas aeruginosa (CRPA).

Data Collection: Demographic details, comorbid conditions, APACHE II scores, presence of septic shock, antibiotic therapy, ICU length of stay, and final patient outcomes were recorded.

Outcome Measures: Primary outcomes included ICU length of stay and all-cause mortality. Secondary outcomes included the need for mechanical ventilation beyond 14 days and the occurrence of septic shock during hospitalization.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as numbers and percentages. Comparisons between CRPA and carbapenem-sensitive P. aeruginosa (CSPA) groups were made using the Chi-square test for categorical variables and Student's t-test for continuous variables. Logistic regression analysis was performed to identify independent predictors of mortality. A p-value <0.05 was considered statistically significant.

Results: A total of 96 patients with culture-confirmed Pseudomonas aeruginosa ventilator-associated pneumonia (VAP) were included in the study. The mean age was 58.4 ± 12.7 years, and 64.6% were male. The mean APACHE II score at ICU admission was 20.8 ± 4.5.

Prevalence of Carbapenem Resistance: The prevalence of carbapenem-resistant Pseudomonas aeruginosa (CRPA) among isolates was 38.5% (n = 37). The remaining 61.5% (n = 59) were carbapenem-sensitive (CSPA) (Table 1).

Table 1: Distribution of CRPA and CSPA among Pseudomonas aeruginosa VAP cases (n = 96)

Isolate type	Frequency (n)	Percentage (%)
CRPA	37	38.5
CSPA	59	61.5

Comparison of Clinical Characteristics: Patients with CRPA infection had a higher proportion of comorbidities such as diabetes mellitus (54.1%) and chronic obstructive pulmonary disease (37.8%) compared to the CSPA group. The difference in APACHE II scores between CRPA and CSPA

patients was statistically significant (p=0.014) (Table 2).

Table 2: Baseline characteristics of CRPA vs. CSPA patients

Variable	CRPA (n=37)	CSPA (n=59)	p-value
Mean age (years)	59.7 ± 11.9	57.6 ± 13.2	0.412
Male sex (%)	25 (67.6)	37 (62.7)	0.628
Diabetes mellitus (%)	20 (54.1)	21 (35.6)	0.048*
COPD (%)	14 (37.8)	13 (22.0)	0.091
Mean APACHE II score	22.1 ± 4.3	19.9 ± 4.5	0.014*

***Student's t-test or Chi-square test; * statistically significant**

Impact on Clinical Outcomes: CRPA infections were associated with a significantly longer ICU stay (18.4 ± 5.3 days) compared to CSPA (12.6 ± 4.1 days, p<0.001). Mortality in the CRPA group was 39.5%, which was significantly higher than the 18.6% observed in the CSPA group (p=0.021). The occurrence of septic shock was also higher in CRPA cases (32.4%) than in CSPA (15.3%) (Table 3).

Table 3: Clinical outcomes in CRPA vs. CSPA patients

Outcome	CRPA (n=37)	CSPA (n=59)	p-value
Mean ICU stay (days)	18.4 ± 5.3	12.6 ± 4.1	<0.001*
Mortality (%)	15 (39.5)	11 (18.6)	0.021*
Septic shock (%)	12 (32.4)	9 (15.3)	0.049*
Ventilation >14 days (%)	18 (48.6)	15 (25.4)	0.018*

***Student's t-test or Chi-square test; * statistically significant**

In summary, CRPA was detected in over one-third of P. aeruginosa VAP cases and was associated with longer ICU stays, higher mortality, and increased risk of septic shock compared to CSPA infections (Tables 1–3).

Discussion

This study found a prevalence of carbapenem-resistant Pseudomonas aeruginosa (CRPA) of 38.5% among ventilator-associated pneumonia (VAP) cases, which is higher than rates reported in some European surveillance studies (15–25%) [1,2] but similar to findings from other developing countries, where prevalence often exceeds 30% [3,4]. The high rate in our ICU likely reflects heavy carbapenem usage, prolonged hospital stays, and cross-transmission due to environmental persistence of P. aeruginosa.

The predominance of comorbid conditions such as diabetes mellitus and chronic obstructive pulmonary disease among CRPA cases mirrors previous reports indicating that underlying illness and immunocompromised states increase susceptibility to multidrug-resistant P. aeruginosa infections [5,6].

The significantly higher APACHE II scores in CRPA patients suggest greater baseline severity of illness, which may contribute to poorer outcomes. Our findings demonstrated a substantial clinical impact of CRPA infections, with longer ICU stays (18.4 ± 5.3 days) and higher mortality (39.5%) compared to carbapenem-sensitive P. aeruginosa (CSPA). Similar trends have been described in multicentre cohort studies, where CRPA VAP was associated with excess mortality of 15–20% and increased healthcare costs [7,8]. Mortality in CRPA is likely multifactorial, involving delayed initiation of effective therapy, limited antibiotic options, and the pathogen's enhanced virulence potential [9,10].

The strong association between CRPA and septic shock (32.4%) aligns with earlier studies showing that multidrug resistance in Gram-negative bacteria correlates with a higher incidence of severe sepsis and organ dysfunction [11]. Additionally, the increased proportion of patients requiring mechanical ventilation for more than 14 days in the CRPA group indicates the pathogen's role in prolonging respiratory support needs [12].

From a microbiological standpoint, carbapenem resistance in P. aeruginosa may result from metallo-β-lactamase production, upregulated efflux pumps, or loss of OprD porin channels [13].

These mechanisms often coexist, conferring resistance to multiple antibiotic classes and making treatment challenging.

Emerging therapeutic options such as ceftolozane/tazobactam and cefiderocol show promise, but cost, availability, and the risk of further resistance remain concerns [14].The findings of this study underscore the urgent need for targeted infection prevention strategies, including antimicrobial stewardship, environmental decontamination, and strict adherence to ventilator care bundles [15]. Rapid diagnostic testing for resistance markers and early optimization of antibiotic regimens could improve outcomes in CRPA-associated VAP.

Conclusion

Carbapenem-resistant Pseudomonas aeruginosa is a significant pathogen in ventilator-associated pneumonia, contributing to longer ICU stays, higher mortality, and increased risk of septic shock. Early detection, strict infection control, and optimized antimicrobial stewardship are essential to improving patient outcomes.

References

1. Pasha SAR, Suresh Kumar Yadav R, Ahmed MI, Chandra P. Rapid detection of carbapenemase-producing multidrug-resistant (MDR) pathogens by modified Carba NP test in ventilator-associated pneumonia (VAP) in elderly patients. Cureus. 2023 Aug 22; 15(8): e43895. doi: 10.7759/cureus.43895. PMID: 37746408.
2. Hegazy EE, Bahey MG, Abo Hagar AM, Elkholy AA, Mohamed EA. Carbapenem-resistant Gram-negative bacilli causing ventilator associated pneumonia: study of MASTDISCS Combi Carba Plus for detection of carbapenemase producing Enterobacterales. Infect Drug Resist. 2022 Oct 31; 15:6331-42. doi: 10.2147/IDR.S385294. PMID: 36337932.
3. Charles MP, Easow JM, Joseph NM, Ravishankar M, Kumar S, Sivaraman U. Aetiological agents of ventilator-associated pneumonia and its resistance pattern—a threat for treatment. Australas Med J. 2013 Sep 30; 6(9):430-4. doi: 10.4066/AMJ.2013.1710. PMID: 24133535.
4. Abdeta A, Bitew A, Fentaw S, Tsige E, Assefa D, Lejisa T, et al. Phenotypic characterization of carbapenem non-susceptible gram-negative bacilli isolated from clinical specimens. PLoS One. 2021 Dec 2; 16(12):e0256556. doi: 10.1371/journal.pone.0256556. PMID: 34855767.
5. Nusrat T, Akter N, Rahman NAA, Godman B, D Rozario DT, Haque M. Antibiotic resistance and sensitivity pattern of Metallo-β-Lactamase producing Gram-negative bacilli in ventilator-associated pneumonia in the intensive care unit of a public medical school hospital in Bangladesh. Hosp Pract (1995). 2020 Aug; 48(3):128-36. doi: 10.1080/21548331.2020.1754687. PMID: 32271642.
6. Werarak P, Kiratisin P, Thamlikitkul V. Hospital-acquired pneumonia and ventilator-associated pneumonia in adults at Siriraj Hospital: etiology, clinical outcomes, and impact of antimicrobial resistance. J Med Assoc Thai. 2010 Jan; 93 Suppl 1:S126-38. PMID: 20364567.
7. Dortet L, Poirel L, Errera C, Nordmann P. CarbAcineto NP test for rapid detection of carbapenemase-producing Acinetobacter spp. J Clin Microbiol. 2014 Jul; 52(7):2359-64. doi: 10.1128/JCM.00594-14. PMID: 24759709.
8. Thakuria B, Singh P, Agrawal S, Asthana V. Profile of infective microorganisms causing ventilator-associated pneumonia: a clinical study from resource-limited intensive care unit. J Anaesthesiol Clin Pharmacol. 2013 Jul; 29(3):361-6. doi: 10.4103/0970-9185.117111. PMID: 24106362.
9. Joseph NM, Sistla S, Dutta TK, Badhe AS, Rasitha D, Parija SC. Ventilator-associated pneumonia in a tertiary care hospital in India: role of multi-drug-resistant pathogens. J Infect Dev Ctries. 2010 May 1; 4(4):218-25. doi: 10.3855/jidc.634. PMID: 20440059.
10. Sarda C, Fazal F, Rello J. Management of ventilator-associated pneumonia (VAP) caused by resistant gram-negative bacteria: which is the best strategy to treat? Expert Rev Respir Med. 2019 Aug; 13(8):787-98. doi: 10.1080/17476348.2019.1632195. PMID: 31210549.
11. Dey A, Bairy I. Incidence of multidrug-resistant organisms causing ventilator-associated pneumonia in a tertiary care hospital: a nine months' prospective study. Ann Thorac Med. 2007 Apr; 2(2):52-7. doi: 10.4103/1817-1737.32230. PMID: 19727346.
12. Bayramoğlu G, Uluçam G, Gençoğlu Özgür Ç, Kılıç AO, Aydın F. [Comparison of the modified Hodge test and the Carba NP test for detection of carbapenemases in Enterobacteriaceae isolates]. Mikrobiyol Bul. 2016 Jan; 50(1):1-10. doi: 10.5578/mb.10861. PMID: 27058324. Turkish.
13. Chittawatanarat K, Jaipakdee W, Chotirosniramit N, Chandacham K, Jirapongcharoenlap T. Microbiology, resistance patterns, and risk factors of mortality in ventilator-associated bacterial pneumonia in a Northern Thai tertiary-care university-based general surgical intensive care unit. Infect Drug Resist. 2014 Aug 16; 7:203-10. doi: 10.2147/IDR.S67267. PMID: 25152627.
14. Baidya S, Sharma S, Mishra SK, Kattel HP, Parajuli K, Sherchand JB. Biofilm formation by pathogens causing ventilator-associated pneumonia at intensive care units in a tertiary care hospital: an armor for refuge. Biomed Res Int. 2021 May 28; 2021:8817700. doi: 10.1155/2021/8817700. PMID: 34136573.
15. Beshah D, Desta AF, Woldemichael GB, Belachew EB, Derese SG, Zelelie TZ, et al. High burden of ESBL and carbapenemase-producing gram-negative bacteria in bloodstream infection patients at a tertiary care hospital in Addis Ababa, Ethiopia. PLoS One. 2023 Jun 27; 18(6):e0287453. doi: 10.1371/journal.pone.0287453. PMID: 37368908.