

Study of Clinical Profile, Management, and Outcomes of Ventilator-Associated Pneumonia in an Intensive Care Unit at a Tertiary Care Centre

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is a major healthcare-associated infection among critically ill patients receiving invasive mechanical ventilation. The increasing prevalence of antimicrobial-resistant pathogens complicates treatment and underscores the importance of institution-specific microbiological surveillance. This study evaluated the clinical characteristics, microbiological profile, antimicrobial resistance patterns, treatment modifications, and clinical outcomes of patients with VAP in a tertiary-care medical intensive care unit (ICU).

Methods: A prospective, hospital-based descriptive observational study was conducted in the medical ICU of Government Medical College and Hospital, Chhatrapati Sambhajanagar, Maharashtra, India, from January to December 2025. A total of 120 adult patients who developed VAP after more than 48 hours of invasive mechanical ventilation were included. Demographic and clinical characteristics, respiratory culture results, antimicrobial susceptibility patterns, treatment modifications, duration of mechanical ventilation, ICU length of stay, complications, and ICU outcomes were assessed. Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean $\pm$ standard deviation or median and interquartile range, as appropriate.

Results: The mean age of the 120 patients was 55.8 ± 16.2 years, and 68.33% were male. Late-onset VAP occurred in 58.33% of patients. Respiratory cultures were positive in 108 patients (90.00%), yielding 118 bacterial isolates, of which 91.53% were Gram-negative organisms. *Acinetobacter baumannii* (33.90%), *Klebsiella pneumoniae* (26.27%), and *Pseudomonas aeruginosa* (18.64%) were the predominant isolates. Multidrug resistance and extensive drug resistance were identified in 66.95% and 27.12% of isolates, respectively. Carbapenem resistance was observed in 80.00% of *A. baumannii*, 67.74% of *K. pneumoniae*, and 50.00% of *P. aeruginosa* isolates. Antimicrobial therapy was modified following

microbiological results in 70.00% of patients. The median ICU stay was 15 days (IQR 10–22), and ICU mortality was 38.33%.

Conclusion: VAP in this tertiary-care ICU was predominantly associated with Gram-negative bacteria and a substantial burden of antimicrobial resistance. These findings highlight the importance of local microbiological surveillance, appropriate respiratory sampling, culture-guided antimicrobial modification, and antimicrobial stewardship to support the management of VAP.

Keywords: Ventilator-Associated Pneumonia; Mechanical Ventilation; Intensive Care Unit; *Acinetobacter baumannii*; Antimicrobial Resistance.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a pulmonary infection that develops in patients receiving invasive mechanical ventilation, typically after at least 48 hours of endotracheal intubation. It is a significant healthcare-associated infection among critically ill patients and is associated with prolonged mechanical ventilation, extended intensive care unit (ICU) stays, increased antimicrobial use, and greater healthcare resource utilization. [1]

Endotracheal intubation bypasses normal airway protective mechanisms, interferes with mucociliary clearance, facilitates microaspiration of colonized oropharyngeal and gastric secretions, and provides a surface for microbial adherence and biofilm formation. [1] Diagnosis remains challenging because fever, leukocytosis, purulent respiratory secretions, worsening oxygenation, and radiological infiltrates are not individually specific for VAP. Consequently, clinical assessment must be interpreted together with appropriate microbiological evaluation and the clinical trajectory of the patient. [2,3]

The microbiological spectrum of VAP varies considerably between geographical regions, hospitals, individual ICUs, and patient populations. Gram-negative bacilli constitute a substantial proportion of VAP pathogens in Indian tertiary-care ICUs, with *Acinetobacter baumannii*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and other Enterobacterales frequently isolated. [4-9] Increasing antimicrobial resistance among these organisms has complicated empirical treatment and contributed to

greater use of broad-spectrum agents. Previous antibiotic exposure, prolonged hospitalization, duration of mechanical ventilation, colonization pressure, and local infection-control practices may influence the likelihood of resistant infection. [3]

International guidelines therefore emphasize the importance of hospital- or ICU-specific antibiograms and recommend reassessment and de-escalation of empirical antimicrobial therapy when microbiological and clinical information permit. [3] Institution-specific information is therefore particularly relevant in large government tertiary-care teaching hospitals receiving patients with diverse medical illnesses and previous healthcare exposure. The present study was undertaken to evaluate the clinical characteristics, microbiological profile, antimicrobial management, and outcomes of patients with VAP in the medical ICU of this tertiary-care centre.

MATERIALS AND METHODS

This hospital-based descriptive observational study was conducted in the intensive care unit of the Department of Medicine, Government Medical College and Hospital, Chhatrapati Sambhajanagar, Maharashtra, India, over a period of 12 months from January 2025 to December 2025. Study was approved by institutional ethical committee.

Inclusion Criteria

- Patients aged ≥ 18 years, admitted to the medical intensive care unit.
- Patients requiring invasive mechanical ventilation for more than 48 hours.

- Patients meeting the predefined clinical criteria for ventilator-associated pneumonia (VAP).

Exclusion Criteria

- Patients with pneumonia documented before initiation of invasive mechanical ventilation.
- Patients developing pneumonia within the first 48 hours of mechanical ventilation.
- Patients with inadequate clinical documentation or unavailable essential microbiological information.

Written informed consent was obtained from the legally authorized representative of each participant. Demographic information, primary diagnosis, associated comorbidities, duration of mechanical ventilation before development of VAP, clinical manifestations, laboratory findings, radiological abnormalities, microbiological findings, antimicrobial therapy, and clinical outcomes were recorded.

VAP was considered in mechanically ventilated patients developing a new or progressive pulmonary infiltrate accompanied by compatible clinical features such as fever or hypothermia, abnormal leukocyte count, purulent tracheal secretions, and/or deterioration in oxygenation. Endotracheal aspirate specimens were collected aseptically before modification of antimicrobial therapy and transported promptly to the microbiology laboratory. Antimicrobial susceptibility testing was performed by [Kirby–Bauer disk diffusion/VITEK 2/broth microdilution] and interpreted according to CLSI M100 criteria. Early-onset VAP was defined as VAP occurring within the first 4 days of mechanical ventilation, whereas VAP

occurring on or after day 5 was classified as late-onset VAP. Clinical outcomes included duration of mechanical ventilation following VAP, ICU length of stay, development of septic shock or acute kidney injury, requirement for tracheostomy, survival to ICU discharge, and ICU mortality.

Statistical Analysis

Data were entered into a structured database and checked for completeness and internal consistency before analysis. Categorical variables were summarized as frequencies and percentages. Continuous variables with an approximately normal distribution were expressed as mean $\pm$ standard deviation, whereas variables with skewed distributions were presented as median and interquartile range (IQR). Microbiological findings and antimicrobial resistance patterns were summarized using frequencies and percentages, with isolate-specific resistance proportions calculated using the corresponding number of isolates as the denominator. Clinical characteristics, antimicrobial treatment patterns, and patient outcomes were analyzed descriptively.

RESULTS

A total of 120 patients with ventilator-associated pneumonia were included. The mean age was 55.8 ± 16.2 years. Eighty-two (68.33%) patients were male and 38 (31.67%) were female. Hypertension was documented in 46 (38.33%) patients and diabetes mellitus in 39 (32.50%). Sepsis or septic illness was the admission category in 36 (30.00%) patients, followed by neurological disorders in 27 (22.50%) and primary respiratory disorders in 22 (18.33%). (Refer Table 1)

Table 1. Baseline demographic and clinical characteristics of patients with VAP (n=120)

Characteristic	n (%) / Value
Age, years, mean $\pm$ SD	55.8 $\pm$ 16.2
Male	82 (68.33)
Female	38 (31.67)
Comorbidities	
Hypertension*	46 (38.33)
Diabetes mellitus*	39 (32.50)

Chronic kidney disease*	17 (14.17)
Chronic obstructive pulmonary disease*	15 (12.50)
Ischaemic heart disease*	11 (9.17)
Primary reason for ICU admission	
Sepsis/septic illness	36 (30.00)
Neurological illness	27 (22.50)
Primary respiratory illness	22 (18.33)
Poisoning/toxicological illness	12 (10.00)
Renal/metabolic illness	11 (9.17)
Other diagnoses	12 (10.00)

*Multiple comorbidities could occur in the same patient.

Late-onset VAP was identified in 70 (58.33%) patients. The median interval between initiation of mechanical ventilation and diagnosis of VAP was 6 days (IQR 4–9). A new or progressive radiological infiltrate

was observed in 110 (91.67%), fever in 96 (80.00%), and purulent respiratory secretions in 91 (75.83%) patients. (Refer Table 2)

Table 2. Clinical characteristics of ventilator-associated pneumonia (n=120)

Variable	n (%) / Value
Early-onset VAP	50 (41.67)
Late-onset VAP	70 (58.33)
Time from ventilation to VAP, median days (IQR)	6 (4–9)
Fever	96 (80.00)
Purulent tracheal secretions	91 (75.83)
Leukocytosis/leukopenia	83 (69.17)
New/progressive radiological infiltrate	110 (91.67)
Worsening oxygenation	75 (62.50)
Positive respiratory culture	108 (90.00)
Negative respiratory culture	12 (10.00)

Respiratory cultures were positive in 108 patients. Among the 108 culture-positive patients, 98 had monomicrobial growth and 10 had two bacterial isolates each, yielding a total of 118 isolates. Gram-negative

organisms accounted for 108 (91.53%) isolates. *A. baumannii*, *K. pneumoniae*, and *P. aeruginosa* together constituted 93 (78.81%) isolates. (Refer Figure 1)

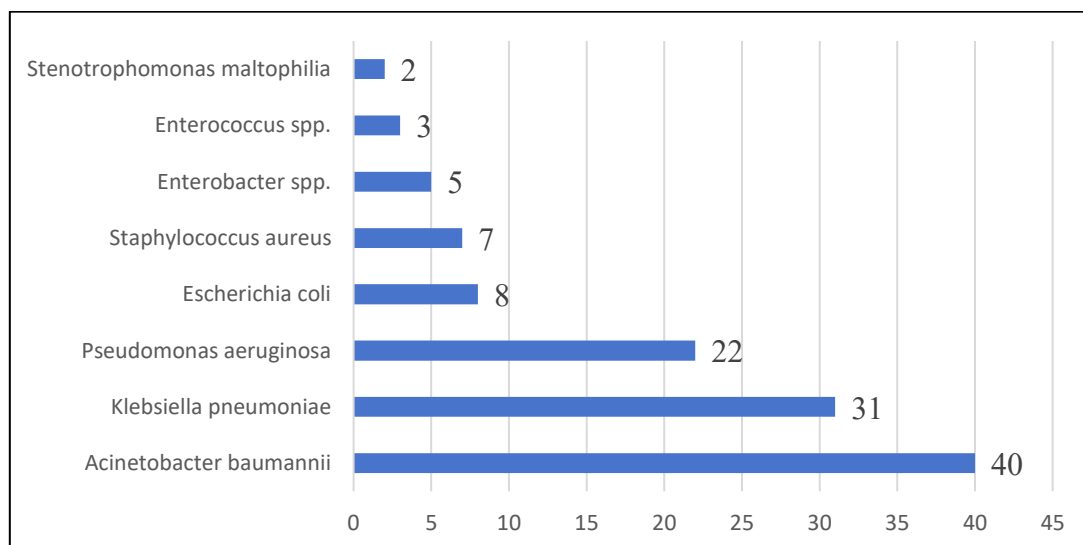


Figure 1 - Microbiological profile of bacterial isolates (n=118 isolates)

Multidrug resistance was identified in 79 (66.95%) isolates and an XDR phenotype in 32 (27.12%). Carbapenem resistance was

observed in 80.00% of *A. baumannii*, 67.74% of *K. pneumoniae*, and 50.00% of *P. aeruginosa* isolates. (Refer Table 3)

Table 3. Antimicrobial resistance characteristics of bacterial isolates

Resistance characteristic	n/N (%)
MDR isolates	79/118 (66.95)
XDR isolates	32/118 (27.12)
Carbapenem-resistant <i>A. baumannii</i>	32/40 (80.00)
Carbapenem-resistant <i>K. pneumoniae</i>	21/31 (67.74)
Carbapenem-resistant <i>P. aeruginosa</i>	11/22 (50.00)
Colistin-susceptible <i>A. baumannii</i>	39/40 (97.50)
Colistin-susceptible <i>K. pneumoniae</i>	30/31 (96.77)
Colistin-susceptible <i>P. aeruginosa</i>	21/22 (95.45)

Microbiological results led to modification of antimicrobial therapy in 84 (70.00%) patients. Escalation or resistance-directed modification was undertaken in 52 (43.33%),

while antimicrobial therapy was de-escalated or narrowed in 32 (26.67%). The median duration of antimicrobial therapy was 8 days (IQR 7–10). (Refer Table 4)

Table 4. Antimicrobial management among patients with VAP (n=120)

Treatment characteristic	n (%)
Meropenem-containing empirical regimen	43 (35.83)
Piperacillin-tazobactam-based regimen	32 (26.67)
Cefoperazone-sulbactam-based regimen	27 (22.50)
Other empirical regimen	18 (15.00)
Therapy modified after microbiological result	84 (70.00)
Escalation/resistance-directed modification	52 (43.33)
De-escalation/narrowing	32 (26.67)
Empirical regimen continued without major modification	36 (30.00)
Antibiotic duration, median days (IQR)	8 (7–10)

Following VAP diagnosis, patients remained mechanically ventilated for a median of 8 days (IQR 5–13), while the median ICU stay was 15 days (IQR 10–22). Septic shock occurred in 44 (36.67%)

patients and acute kidney injury in 39 (32.50%). Seventy-four (61.67%) patients survived to ICU discharge, while 46 (38.33%) died during ICU admission. (Refer Table 5)

Table 5. Clinical outcomes of patients with VAP (n=120)

Outcome	n (%) / Value
Mechanical ventilation after VAP, median days (IQR)	8 (5–13)
ICU stay, median days (IQR)	15 (10–22)
Septic shock	44 (36.67)
Acute kidney injury	39 (32.50)
Tracheostomy	31 (25.83)
Survived ICU admission	74 (61.67)
ICU mortality	46 (38.33)

DISCUSSION

In the present study, principal observations were the predominance of Gram-negative bacteria, particularly *A. baumannii*, *K. pneumoniae*, and *P. aeruginosa*, a substantial burden of multidrug resistance,

and frequent requirement for modification of empirical antimicrobial therapy following availability of microbiological results. Late-onset VAP accounted for 58.33% of cases, 90.00% of patients had positive respiratory cultures, and Gram-negative organisms

comprised 91.53% of all bacterial isolates. The findings reinforce the importance of local microbiological surveillance when selecting empirical antimicrobial therapy in critically ill ventilated patients.

The mean age of patients was 55.8 years, and 68.33% were male. Hypertension and diabetes mellitus were frequently associated comorbidities. The demographic pattern is broadly comparable with Indian ICU studies, although age and comorbidity profiles vary considerably according to ICU specialization and referral patterns. Zirpe et al.,^[9] evaluated 457 mechanically ventilated neurocritical-care patients in India, of whom 114 developed VAP, and identified diabetes, prolonged ventilation, male sex, and low Glasgow Coma Scale score among variables associated with VAP. These observations suggest that host characteristics and duration of critical-care exposure should be considered alongside microbiological factors when evaluating patients at risk of VAP.

Late-onset VAP accounted for 58.33% of cases, while 41.67% were classified as early onset. Gunalan et al.,^[5] in a prospective study from the medical ICU of JIPMER, evaluated 273 mechanically ventilated patients and identified VAP in 93; 53 (56.9%) had early-onset and 40 (43.1%) had late-onset VAP. Variation in the proportion of early- and late-onset disease between centres may reflect differences in referral patterns, prior hospitalization, previous antibiotic exposure, duration of ventilation, and operational definitions. Furthermore, timing of VAP alone is an imperfect marker of antimicrobial resistance, and contemporary treatment decisions should integrate individual risk factors and local antimicrobial susceptibility data.^[3]

Gram-negative bacteria accounted for 91.53% of isolates in the present study. This pattern is consistent with several reports from Indian tertiary-care ICUs. Sangale et al.,^[4] evaluated 827 bacterial isolates from patients with clinically suspected VAP and reported 780 (94.32%) Gram-negative organisms. *A. baumannii* accounted for

38.7%, *P. aeruginosa* for 17.5%, and *K. pneumoniae* for 16.6% of isolates. Their observations are comparable with the present distribution, in which *A. baumannii*, *K. pneumoniae*, and *P. aeruginosa* collectively accounted for 78.81% of isolates.

A. baumannii was the leading pathogen, accounting for 33.90% of bacterial isolates. Its prominence has been repeatedly documented in Indian ICU studies.^[4,6-9] Mathai et al.,^[6] also observed *Acinetobacter* species as an important VAP pathogen. Chaudhury et al.,^[7] documented substantial antimicrobial resistance among VAP-associated Gram-negative bacteria in a tertiary-care Indian hospital.^[7] More recently, Zirpe et al.,^[9] reported *A. baumannii* in 31.58%, *K. pneumoniae* in 28.95%, and *P. aeruginosa* in 13.16% of VAP cases in a neurocritical-care setting. The similarity in the predominance of these organisms across different Indian institutions emphasizes their importance in contemporary ICU-acquired respiratory infection.

K. pneumoniae represented 26.27% of isolates and was the second frequently isolated pathogen, while *P. aeruginosa* accounted for 18.64%. The proportion of individual pathogens varies considerably among studies. Sangale et al.,^[4] reported *K. pneumoniae* in 16.6% and *P. aeruginosa* in 17.5% of isolates, whereas differences have been reported from other tertiary-care settings.^[5-8] These variations may be related to differences in patient population, antibiotic exposure, infection-control practices, duration of hospitalization, specimen-processing methods, and institutional microbial ecology.

The antimicrobial resistance pattern was clinically important. Overall, 66.95% of isolates fulfilled MDR criteria, while 27.12% were classified as XDR. The internationally accepted terminology proposed by Magiorakos et al.,^[10] provides a standardized framework for classifying multidrug resistance across clinically relevant bacterial species.

The MDR burden observed in Indian VAP studies has varied considerably. Sangale et al., [4] reported MDR among 87.5% of Gram-negative isolates reflecting the particularly high antimicrobial selection pressure likely to occur in immunocompromised and repeatedly hospitalized patients. Zirpe et al., [9] subsequently reported MDR organisms in 81.58% and XDR organisms in 12.28% of VAP isolates in an Indian neurocritical-care population. Differences between studies must therefore be interpreted in relation to patient mix and local prescribing and resistance patterns.

Carbapenem resistance was particularly prominent in *A. baumannii*, affecting 80.00% of isolates, followed by *K. pneumoniae* at 67.74% and *P. aeruginosa* at 50.00%. High resistance among non-fermenting Gram-negative bacilli has been described in earlier Indian studies. [4,7,8] Such findings have important implications for empirical therapy because inappropriate initial treatment in critically ill patients may be detrimental, whereas unnecessary indiscriminate use of last-line agents may accelerate resistance. Accordingly, empirical regimens should be guided by illness severity, individual risk factors, recent antimicrobial exposure, and an up-to-date ICU antibiogram rather than by a uniform hospital-wide approach. [3,11]

Antimicrobial therapy was modified following microbiological results in 70.00% of patients. Escalation or resistance-directed modification was required in 43.33%, whereas de-escalation was performed in 26.67%. This finding highlights the practical importance of obtaining an appropriate respiratory specimen before altering antimicrobial therapy when the patient's clinical condition allows. The ATS/IDSA guideline recommends tailoring initial therapy according to local resistance data and subsequently narrowing antimicrobial coverage when microbiological and clinical findings permit. [3] More recent reviews similarly emphasize early reassessment of empirical therapy, appropriate microbiological sampling, and

avoidance of unnecessary broad-spectrum antimicrobial exposure. [11]

The median antimicrobial duration was 8 days. Contemporary recommendations generally favour approximately 7 days of treatment for VAP when patients demonstrate an adequate clinical response, while allowing individualized modification according to the infecting organism, complications, response to therapy, and adequacy of source control. [1,3] Prolonged antimicrobial therapy without a clear clinical indication increases drug exposure and may contribute to adverse effects and antimicrobial selection pressure.

The median ICU stay was 15 days, and patients required a median of 8 additional days of mechanical ventilation after VAP diagnosis. Mathai et al., [6] reported substantially longer ICU and hospital stays among patients developing VAP compared with ventilated patients without VAP. Zirpe et al., [9] similarly reported longer ICU stay among VAP patients. However, prolonged ICU stay and VAP have a complex bidirectional relationship: prolonged ventilation increases opportunity for VAP, while VAP itself may prolong respiratory support and ICU treatment. A descriptive cohort therefore cannot establish the direction or magnitude of causality.

ICU mortality was 38.33%. This represents crude mortality among patients with VAP rather than mortality directly attributable to VAP. Critically ill patients frequently have severe underlying disease, sepsis, multiorgan dysfunction, neurological injury, or other conditions that independently contribute to death. Papazian et al., [1] emphasized that attributable mortality from VAP is substantially lower than crude mortality and varies among patient populations. Mathai et al., [6] observed prolonged ICU and hospital stay among VAP patients without demonstrating a significant difference in overall mortality, while Zirpe et al., [9] similarly reported increased ICU stay but no significant mortality difference between VAP and non-VAP groups. Therefore, the present

mortality figure should be interpreted as an outcome occurring in patients with VAP rather than as mortality caused solely by pneumonia.

Diagnostic uncertainty must also be considered when interpreting VAP studies. Fernando et al., [2] in a systematic review and meta-analysis, demonstrated limitations in the diagnostic accuracy of commonly used clinical findings and respiratory sampling strategies when compared with histopathological reference standards. Positive endotracheal cultures may represent colonization rather than invasive pulmonary infection, particularly after prolonged ventilation. Clinical findings, imaging, microbiology, oxygenation, and the overall course of illness should consequently be interpreted together rather than relying on a single diagnostic parameter. [12]

Timely microbiological sampling, review of culture results, de-escalation when appropriate, appropriate duration of treatment, and implementation of established VAP-prevention measures can collectively improve antimicrobial use and potentially limit further emergence of resistance. [13,11]

The principal strength of the present study was the integrated assessment of clinical characteristics, microbiological profile, antimicrobial resistance patterns, treatment modification, and short-term ICU outcomes among patients with VAP over a defined one-year period. The study also provides locally relevant microbiological and resistance data that may inform antimicrobial stewardship in a tertiary-care medical ICU.

However, the single-centre descriptive design limits generalizability. The absence of a mechanically ventilated non-VAP comparison group precluded estimation of VAP-attributable effects on duration of ventilation, ICU stay, or mortality. These findings should therefore be interpreted as descriptive outcomes among patients diagnosed with VAP rather than effects attributable specifically to VAP.

Limitations

The study was conducted at a single tertiary care centre with a relatively small sample size of 120 patients, which may limit the generalizability of the findings to other ICU settings. The study was conducted over one year and focused on adult VAP patients, so longer-term trends in antimicrobial resistance and outcomes, as well as applicability to other patient populations, could not be assessed.

CONCLUSION

Ventilator-associated pneumonia in this tertiary-care medical ICU was predominantly associated with Gram-negative bacteria, particularly *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. A substantial proportion of bacterial isolates demonstrated multidrug resistance and carbapenem resistance, and microbiological findings frequently resulted in modification of empirical antimicrobial therapy.

Patients remained mechanically ventilated for a median of 8 days following VAP diagnosis and had a median ICU stay of 15 days; septic shock, acute kidney injury, and crude ICU mortality were observed in 36.67%, 32.50%, and 38.33%, respectively. These findings emphasize the importance of appropriate respiratory sampling, institution-specific microbiological surveillance, rational empirical antimicrobial selection, and timely culture-guided modification of therapy in patients with suspected VAP.

Declaration

Ethical Approval: Approved

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