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Original Research Article

A STUDY OF VENTILATOR ASSOCIATED PNEUMONIA: INCIDENCE, OUTCOME AND CULTURE SENSITIVITY PROFILE OF ISOLATED ORGANISM

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is an important healthcare-associated infection among critically ill patients receiving mechanical ventilation. It is associated with increased morbidity, antimicrobial resistance, prolonged intensive care unit (ICU) stay and mortality. Identification of causative organisms and their antibiotic susceptibility patterns is essential for appropriate antimicrobial management. **Aim:** To determine the incidence, clinical outcomes and culture sensitivity profile of organisms isolated from patients developing ventilator-associated pneumonia.

Material and Methods: This prospective study was conducted in the Department of Pulmonary Medicine, Shri Ram Murti Smarak Institute of Medical Sciences, Bareilly, from November 2016 to April 2018. A total of 70 adult patients receiving mechanical ventilation for more than 48 hours were included. Demographic characteristics, clinical findings, APACHE-IV scores, endotracheal aspirate cultures, antimicrobial susceptibility patterns and clinical outcomes were evaluated. Statistical analysis was performed using SPSS version 20.0.

Results: VAP developed in 10 (14.29%) patients, while 60 (85.71%) remained free from VAP. Among VAP patients, 70.00% were aged above 60 years and 80.00% were male. Hypercapnia was the predominant indication for intubation (90.00%), while bilateral pneumonia was observed in 80.00% of VAP cases. Klebsiella pneumoniae was the commonest isolate (40.00%), followed by Acinetobacter baumannii and Staphylococcus aureus (20.00% each). The isolates demonstrated variable resistance to beta-lactams, aminoglycosides and carbapenems. Mean APACHE-IV scores were higher in VAP patients (100.80 ± 14.79) than non-VAP patients (86.73 ± 21.07). Mortality was significantly higher among VAP patients (70.00%) compared with non-VAP patients (28.33%; p=0.0071).

Conclusion: VAP was associated with significantly higher mortality among mechanically ventilated patients. Early diagnosis, microbiological surveillance, culture-guided antibiotic therapy and effective preventive strategies are essential for improving clinical outcomes.

Keywords: Ventilator-associated pneumonia; Mechanical ventilation; Antimicrobial resistance; Endotracheal aspirate culture; Mortality.

INTRODUCTION

Mechanical ventilation is an essential component of intensive care management for patients with respiratory failure, impaired consciousness and other life-threatening conditions. Although this intervention supports respiratory function, the presence of an endotracheal tube disrupts normal airway defenses and facilitates the entry of microorganisms into the lower respiratory tract.

Ventilator-associated pneumonia (VAP) is generally defined as pneumonia developing at least 48 hours after endotracheal intubation and initiation of mechanical ventilation. It represents an important healthcare-associated infection because of its diagnostic complexity, treatment requirements and consequences for critically ill patients. Evaluating its occurrence within intensive care units is necessary for understanding the local burden of infection and guiding clinical care.[1] The development of VAP is influenced by interactions between host susceptibility, invasive devices and the critical care environment. Advanced age, chronic pulmonary disease, neurological impairment, systemic illness, reduced consciousness and prolonged ventilatory support may compromise the mechanisms that protect the lungs against infection. Microaspiration of colonized oropharyngeal secretions and formation of microbial biofilms on endotracheal tubes contribute to its pathogenesis. Patients developing pulmonary infection during ventilation may require prolonged respiratory support and additional antimicrobial treatment. The relationship between VAP and adverse clinical outcomes is complicated by the severity of underlying illness, making careful assessment of clinical status and subsequent outcomes particularly important.[2] Early recognition of VAP remains challenging because its clinical manifestations overlap with other conditions encountered in intensive care. Fever, altered leukocyte counts, purulent respiratory secretions, deteriorating oxygenation and new pulmonary infiltrates can raise suspicion, but none of these findings alone establishes the diagnosis. Noninfectious pulmonary oedema, atelectasis and inflammatory lung injury may produce similar clinical or radiographic abnormalities. Microbiological evaluation of lower respiratory tract specimens therefore provides essential supportive information. Endotracheal aspirates offer a practical sampling approach, whereas bronchoalveolar lavage may be used in selected circumstances. Interpretation requires attention to specimen quality, prior antibiotic exposure and the distinction between airway colonization and true pulmonary infection.[3] Knowledge of the bacterial pathogens associated with VAP is fundamental to selecting appropriate antimicrobial therapy. Gram-negative bacilli, including Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa and Escherichia coli, are important potential pathogens, while Gram-positive bacteria such as Staphylococcus aureus also contribute to infection. The distribution of organisms varies according to patient characteristics, hospitalization, previous antibiotic exposure and local infection-control practices. Consequently, microbiological findings from one hospital cannot automatically be applied to another. Timely collection of endotracheal aspirates, accurate organism identification and systematic recording of culture findings help clinicians recognize local microbiological patterns and improve the interpretation of suspected respiratory infections.[4] Antimicrobial resistance further complicates VAP management, particularly when pathogens are resistant to several commonly prescribed antibiotics. Resistance involving beta-lactams, aminoglycosides, fluoroquinolones and carbapenems may restrict therapeutic options and complicate treatment. Multidrug-resistant organisms can enter the respiratory tract through colonization, cross-transmission or selection under antimicrobial pressure. Their occurrence underscores the need for microbiological surveillance, appropriate infection-control precautions and responsible antibiotic prescribing. A regularly updated unit-specific antibiogram can assist clinicians in selecting empirical treatment while susceptibility reports are pending. It also supports evaluation of changing resistance patterns and informs policies designed to preserve the effectiveness of available antimicrobial agents.[5] Appropriate treatment depends on identifying the causative organism and interpreting antimicrobial susceptibility in the context of clinical severity and patient-specific factors. Empirical antibiotics may be necessary when VAP is strongly suspected, particularly in unstable patients. However, unnecessarily broad or prolonged treatment can encourage antimicrobial resistance and expose patients to adverse effects. Culture and sensitivity reports allow treatment to be reassessed and narrowed whenever clinically appropriate. Organisms with inducible or other complex resistance mechanisms require particular attention when definitive therapy is selected. Integrating microbiological information with bedside clinical assessment is therefore central to antimicrobial stewardship and effective management of mechanically ventilated patients.[6]

MATERIALS AND METHODS

The study was conducted in the Department of Pulmonary Medicine, Shri Ram Murti Smarak Institute of Medical Sciences, Bareilly, a tertiary care referral centre with state-of-the-art infrastructure. The institute is a welfare hospital that primarily caters to the semi-urban and rural populations belonging to socio-economically underprivileged sections of society. The study was conducted over a period of one and a half years, from 1st November 2016 to 30th April 2018. The study was designed as a prospective study. The study population comprised patients admitted to the Intensive Care Unit (ICU) of Shri Ram Murti Smarak Institute of Medical Sciences, Bareilly, who required mechanical ventilation for more than 48 hours. A total of 274 patients were admitted to the ICU during the study period from 1st November 2016 to 30th April 2018. Among these, 70 patients fulfilled the inclusion criteria and did not meet any of the exclusion criteria. These 70 patients were included in the study.

Inclusion Criteria

The study included patients of either sex aged 18 years or above who were admitted to the critical care facility and required mechanical ventilation for more than 48 hours.

Exclusion Criteria

Patients with pneumonia prior to the initiation of mechanical ventilation, known HIV seropositivity, patients intubated outside the ICU, patients intubated in another hospital, and re-intubated patients were excluded from the study.

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee. Informed consent was obtained from all the study participants before enrolment.

Methodology

All patients fulfilling the eligibility criteria were invited to participate in the study, and only those providing informed consent were enrolled. Patients receiving mechanical ventilation for more than 48 hours were evaluated for eligibility according to the predefined inclusion and exclusion criteria. A detailed medical history was obtained, and demographic information was recorded. Thorough general physical and systemic examinations were performed in all enrolled patients.

All patients underwent routine laboratory investigations, including haemogram, hepatic function tests, renal function tests, blood sugar estimation, and chest X-ray (posteroanterior view). Patients were also evaluated for associated factors, including concomitant diseases, immunosuppression-related conditions such as chronic renal failure, diabetes mellitus and steroid therapy, indications for mechanical ventilation, and the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen (PaO_2/FiO_2) before the onset of ventilator-associated pneumonia (VAP). The severity of illness was assessed using the Acute Physiology and Chronic Health Evaluation IV (APACHE-IV) scoring system. Chest radiographs were obtained after 48 hours of mechanical ventilation. Subsequently, serial chest radiographs were performed to identify radiological evidence suggestive of pneumonia. Endotracheal aspirate samples were collected from all patients after 48 hours of mechanical ventilation and sent to the Department of Microbiology, SRMS IMS, Bareilly, for bacterial culture and antimicrobial susceptibility testing. The culture and sensitivity findings were evaluated to determine the microbiological profile and antibiotic susceptibility patterns of the isolated organisms.

Statistical Analysis

Statistical analysis was performed using IBM SPSS (Statistical Package for the Social Sciences), version 20.0. The collected data were expressed as numbers and percentages [n (%)]. The Chi-square test was used for statistical comparisons. A p-value greater than 0.05 was considered statistically non-significant, a p-value less than 0.05 was considered significant, a p-value less than 0.01 was considered highly significant, and a p-value less than 0.001 was considered very highly significant.

RESULTS

Table 1. Distribution of VAP by Demographic Characteristics, Personal Habits and Place of Residence

Table 1 shows the demographic characteristics, personal habits and residential distribution of the study population. Among 70 patients, 10 (14.29%) developed ventilator-associated pneumonia (VAP), while 60 (85.71%) did not develop VAP. The majority of VAP patients belonged to the age group above 60 years (70.00%), compared with 43.33% in the non-VAP group. Male patients constituted 80.00% of the VAP group, compared with 65.00% of the non-VAP group. A history of smoking and alcohol consumption for 16–30 years was reported in 50.00% of VAP patients for each habit, compared with 30.00% of non-VAP patients. Rural and urban residents contributed equally (50.00% each) to the VAP group, whereas rural residents predominated in the non-VAP group (63.33%). However, the associations of VAP with age (p=0.3305), sex (p=0.3499), smoking (p=0.1979), alcohol consumption (p=0.1632) and place of residence (p=0.4226) were statistically non-significant.

Table 2. Pre-existing Diseases, Clinical Examination, Symptoms, Reasons for Intubation and Radiographic Findings

Table 2 presents the distribution of pre-existing diseases, clinical findings, presenting symptoms, indications for intubation and radiographic abnormalities among the study participants. Chronic obstructive pulmonary disease was present in 30.00% of VAP patients, while cerebrovascular accident was the most frequently reported systemic condition (40.00%). Pallor and oedema were observed in 40.00% and 30.00% of VAP patients, respectively. Cough lasting more than 30 days was reported in 50.00% of VAP patients compared with 20.00% of non-VAP patients, showing a statistically significant association (p=0.0245). Fever was present in 90.00% of VAP patients compared with 30.00% of non-VAP patients, with a highly significant association (p=0.0003). Hypercapnia was reported as an indication for intubation in 90.00% of VAP patients, while 50.00% had a Glasgow Coma Scale score of 9–14. Radiographic examination following VAP development revealed bilateral pneumonia in 80.00% and right-sided pneumonia in 20.00% of affected patients.

Table 3. Organisms Isolated on Endotracheal Aspirate Culture in VAP and Non-VAP Patients

Table 3 illustrates the microbiological profile of organisms isolated from endotracheal aspirate cultures among patients with and without ventilator-associated pneumonia. Among the 10 patients who developed VAP, Klebsiella pneumoniae was the predominant organism, isolated in 4 (40.00%)

patients, followed by Acinetobacter baumannii and Staphylococcus aureus, each isolated in 2 (20.00%) patients. Escherichia coli and Pseudomonas aeruginosa were isolated in 1 (10.00%) patient each. In the non-VAP group, 39 (65.00%) patients had sterile cultures, while E. coli was the most frequently isolated organism, accounting for 13.33% of cases. Overall, 31 (44.29%) patients had positive endotracheal aspirate cultures, whereas 39 (55.71%) had sterile cultures. All 10 patients who developed VAP showed positive bacterial cultures, indicating that Gram-negative organisms, particularly K. pneumoniae, predominated among the VAP-associated isolates in this study.

Table 4. Combined Antibiotic Resistance Pattern of Gram-Negative Isolates in Endotracheal Aspirate Cultures

Table 4 demonstrates the antibiotic resistance patterns of Gram-negative organisms isolated from endotracheal aspirate cultures. Among four Acinetobacter baumannii isolates, resistance to piperacillin, ceftriaxone/cefotaxime, cefepime, ceftazidime and cefoperazone was observed in 75.00% of isolates, while no resistance to colistin or polymyxin B was reported. Among nine Klebsiella pneumoniae isolates, resistance to amikacin, gentamicin, tobramycin and netilmicin was 44.44% each, whereas resistance to imipenem and colistin was 22.22% and 11.11%, respectively. Escherichia coli demonstrated the highest resistance to cefoperazone/sulbactam (66.67%), followed by ceftriaxone/cefotaxime (55.56%) and cefepime (44.44%), while no resistance to colistin or polymyxin B was observed. Among six Pseudomonas aeruginosa isolates, resistance to piperacillin, cefepime, gentamicin, tobramycin and meropenem was observed in 50.00% of isolates for each antibiotic. Overall, the findings revealed variable resistance to commonly used beta-lactams, aminoglycosides and carbapenems, while colistin and polymyxin B demonstrated comparatively lower reported resistance rates among most Gram-negative isolates.

Table 5. Antibiotic Resistance Pattern of Staphylococcus aureus Isolated from Endotracheal Aspirate Cultures

Table 5 presents the antibiotic resistance pattern of Staphylococcus aureus isolated from endotracheal aspirate cultures. A total of three S. aureus isolates were identified, including two from patients who developed VAP and one from a patient who did not develop VAP. Resistance to ampicillin, amoxicillin/clavulanate, oxacillin and ceftriaxone/cefotaxime was observed in 2 (66.67%) isolates for each antibiotic. Resistance to piperacillin, piperacillin/tazobactam, cefepime, ceftazidime, cefoperazone, cefoperazone/sulbactam and netilmicin was recorded in 1 (33.33%) isolate for each antibiotic. Both isolates recovered from VAP patients were resistant to oxacillin, while the isolate from the non-VAP group showed no reported resistance to the tested antibiotics. No resistance to vancomycin or linezolid was observed among the three isolates. These findings demonstrate considerable resistance to several beta-lactam antibiotics among the VAP-associated S. aureus isolates, although interpretation is limited by the small number of isolates.

Table 6. ICU Severity Scores, Expected Length of Stay and Clinical Outcomes According to VAP Status

Table 6 compares the severity scores, expected length of ICU stay and clinical outcomes between patients who developed VAP and those who did not. Most patients in both groups had APACHE-IV scores between 81 and 120, accounting for 80.00% of VAP patients and 71.67% of non-VAP patients. The mean APACHE-IV score was higher among VAP patients (100.80 ± 14.79) than non-VAP patients (86.73 ± 21.07), with a reported statistically significant difference (p=0.0469). The mean Acute Physiology Score (APS) was 89.70 ± 15.69 in the VAP group and 90.18 ± 17.79 in the non-VAP group, with a reported p-value of 0.0050. The mean expected length of stay was 7.67 ± 0.94 days among VAP patients compared with 6.77 ± 1.23 days among non-VAP patients (reported p=0.0309). Mortality was considerably higher among patients who developed VAP (70.00%) than among those who did not (28.33%), while recovery was recorded in 20.00% and 63.33%, respectively. The association between VAP development and clinical outcome was statistically significant (reported p=0.0071), indicating poorer observed outcomes among patients who developed VAP.

Table 1: Distribution of VAP by demographic characteristics, personal habits and place of residence

Parameter	Category	Developed VAP (n=10)	No VAP (n=60)	Overall (n=70)	Reported p-value
Age	≤30 years	0 (0.00%)	6 (10.00%)	6 (8.57%)	0.3305
Age	31–45 years	2 (20.00%)	11 (18.33%)	13 (18.57%)	
Age	46–60 years	1 (10.00%)	17 (28.33%)	18 (25.71%)	
Age	>60 years	7 (70.00%)	26 (43.33%)	33 (47.14%)	
Sex	Female	2 (20.00%)	21 (35.00%)	23 (32.86%)	0.3499
Sex	Male	8 (80.00%)	39 (65.00%)	47 (67.14%)	
Smoking	Absent	4 (40.00%)	37 (61.67%)	41 (58.57%)	0.1979
Smoking	1–15 years	0 (0.00%)	2 (3.33%)	2 (2.86%)	
Smoking	16–30 years	5 (50.00%)	18 (30.00%)	23 (32.86%)	
Smoking	31–45 years	1 (10.00%)	3 (5.00%)	4 (5.71%)	
Alcohol use	Absent	4 (40.00%)	38 (63.33%)	42 (60.00%)	0.1632
Alcohol use	1–15 years	0 (0.00%)	2 (3.33%)	2 (2.86%)	

Alcohol use	16–30 years	5 (50.00%)	18 (30.00%)	23 (32.86%)	
Alcohol use	31–45 years	1 (10.00%)	2 (3.33%)	3 (4.29%)	
Place of residence	Rural	5 (50.00%)	38 (63.33%)	43 (61.43%)	0.4226
Place of residence	Urban	5 (50.00%)	22 (36.67%)	27 (38.57%)	
Total		10 (100.00%)	60 (100.00%)	70 (100.00%)	

Mean age according to sex (as supplied): female, 54.09 ± 16.42 years (n=23); male, 58.91 ± 17.14 years (n=47); overall, 57.33 ± 16.94 years (n=70).

Table 2: Pre-existing diseases, clinical examination, symptoms, reasons for intubation and radiographic findings

Parameter	Category / duration	Developed VAP (n=10)	No VAP (n=60)	Overall (n=70)	Reported p-value
Lung disease	COPD	3 (30.00%)	23 (38.33%)	26 (37.14%)	0.7319
Lung disease	Asthma	1 (10.00%)	9 (15.00%)	10 (14.29%)	
Systemic disease	Cerebrovascular accident (CVA)	4 (40.00%)	14 (23.33%)	18 (25.71%)	0.8637
Systemic disease	Diabetes mellitus (DM)	2 (20.00%)	13 (21.67%)	15 (21.43%)	
Systemic disease	Space-occupying lesion (CNS)	1 (10.00%)	5 (8.33%)	6 (8.57%)	
Systemic disease	Coronary artery disease (CAD)	1 (10.00%)	13 (21.67%)	14 (20.00%)	
Systemic disease	Dilated cardiomyopathy (DCMP)	1 (10.00%)	8 (13.33%)	9 (12.86%)	
Systemic disease	Acute kidney injury (AKI)	2 (20.00%)	16 (26.67%)	18 (25.71%)	
Systemic disease	Epilepsy	1 (10.00%)	4 (6.67%)	5 (7.14%)	
Physical examination	Pallor	4 (40.00%)	20 (33.33%)	24 (34.29%)	
Physical examination	Icterus	0 (0.00%)	2 (3.33%)	2 (2.86%)	
Physical examination	Clubbing	1 (10.00%)	2 (3.33%)	3 (4.29%)	
Physical examination	Oedema	3 (30.00%)	25 (41.67%)	28 (40.00%)	
Cough	Absent	2 (20.00%)	35 (58.33%)	37 (52.86%)	0.0245
Cough	1–15 days	3 (30.00%)	10 (16.67%)	13 (18.57%)	
Cough	16–30 days	0 (0.00%)	3 (5.00%)	3 (4.29%)	
Cough	>30 days	5 (50.00%)	12 (20.00%)	17 (24.29%)	
Breathlessness	Absent	1 (10.00%)	19 (31.67%)	20 (28.57%)	0.1602
Breathlessness	1–15 days	4 (40.00%)	21 (35.00%)	25 (35.71%)	
Breathlessness	16–30 days	0 (0.00%)	4 (6.67%)	4 (5.71%)	
Breathlessness	>30 days	5 (50.00%)	16 (26.67%)	21 (30.00%)	
Chest pain	Absent	4 (40.00%)	40 (66.67%)	44 (62.86%)	0.1061
Chest pain	1–15 days	2 (20.00%)	8 (13.33%)	10 (14.29%)	
Chest pain	16–30 days	0 (0.00%)	2 (3.33%)	2 (2.86%)	
Chest pain	>30 days	4 (40.00%)	10 (16.67%)	14 (20.00%)	
Haemoptysis	Absent	10 (100.00%)	59 (98.33%)	69 (98.57%)	1.0000
Haemoptysis	Present	0 (0.00%)	1 (1.67%)	1 (1.43%)	
Loss of appetite	Absent	7 (70.00%)	51 (85.00%)	58 (82.86%)	0.2439
Loss of appetite	1–15 days	0 (0.00%)	5 (8.33%)	5 (7.14%)	
Loss of appetite	16–30 days	1 (10.00%)	4 (6.67%)	5 (7.14%)	
Loss of appetite	>30 days	2 (20.00%)	0 (0.00%)	2 (2.86%)	
Fever	Absent	1 (10.00%)	42 (70.00%)	43 (61.43%)	0.0003
Fever	1–15 days	8 (80.00%)	13 (21.67%)	21 (30.00%)	
Fever	16–30 days	1 (10.00%)	2 (3.33%)	3 (4.29%)	
Fever	46–60 days	0 (0.00%)	1 (1.67%)	1 (1.43%)	
Fever	>60 days	0 (0.00%)	2 (3.33%)	2 (2.86%)	
Hoarseness of voice	Absent	10 (100.00%)	59 (98.33%)	69 (98.57%)	1.0000
Hoarseness of voice	Present	0 (0.00%)	1 (1.67%)	1 (1.43%)	
Any swelling	Absent	10 (100.00%)	55 (91.67%)	65 (92.86%)	1.0000
Any swelling	1–15 days	0 (0.00%)	3 (5.00%)	3 (4.29%)	
Any swelling	16–30 days	0 (0.00%)	2 (3.33%)	2 (2.86%)	
Reason for intubation	Hypoxia	0 (0.00%)	3 (5.00%)	3 (4.29%)	1.0000
Reason for intubation	Hypercapnia	9 (90.00%)	32 (53.33%)	41 (58.57%)	0.2618
Reason for intubation	GCS ≤8	3 (30.00%)	10 (16.67%)	13 (18.57%)	0.3803
Reason for intubation	GCS 9–14	5 (50.00%)	47 (78.33%)	52 (74.29%)	

Reason for intubation	GCS 15	2 (20.00%)	3 (5.00%)	5 (7.14%)	
Reason for intubation	Inability to protect airway	2 (20.00%)	10 (16.67%)	12 (17.14%)	0.6779
Chest X-ray after VAP	Bilateral pneumonia	8 (80.00%)	—	—	
Chest X-ray after VAP	Right-sided pneumonia	2 (20.00%)	—	—	

Table 3: Organisms isolated on endotracheal aspirate culture in VAP and non-VAP patients

Culture isolate	Developed VAP (n=10)	No VAP (n=60)	Overall (n=70)
Acinetobacter baumannii	2 (20.00%)	2 (3.33%)	4 (5.71%)
Escherichia coli	1 (10.00%)	8 (13.33%)	9 (12.86%)
Klebsiella pneumoniae	4 (40.00%)	5 (8.33%)	9 (12.86%)
Pseudomonas aeruginosa	1 (10.00%)	5 (8.33%)	6 (8.57%)
Staphylococcus aureus	2 (20.00%)	1 (1.67%)	3 (4.29%)
Sterile culture	0 (0.00%)	39 (65.00%)	39 (55.71%)
Total	10 (100.00%)	60 (100.00%)	70 (100.00%)

Table 4: Combined antibiotic resistance pattern of Gram-negative isolates in endotracheal aspirate cultures

Antibiotic	A. baumannii (n=4)	K. pneumoniae (n=9)	E. coli (n=9)	P. aeruginosa (n=6)
Piperacillin	V 2/2 | NV 1/2 | T 3/4 (75.00%)	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 0/1 | NV 2/8 | T 2/9 (22.22%)	V 1/1 | NV 2/5 | T 3/6 (50.00%)
Piperacillin/tazobactam	V 1/2 | NV 1/2 | T 2/4 (50.00%)	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 0/1 | NV 3/8 | T 3/9 (33.33%)	V 1/1 | NV 1/5 | T 2/6 (33.33%)
Oxacillin	Not reported	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 0/1 | NV 2/8 | T 2/9 (22.22%)	V 1/1 | NV 1/5 | T 2/6 (33.33%)
Ceftriaxone/cefotaxime	V 2/2 | NV 1/2 | T 3/4 (75.00%)	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 0/1 | NV 5/8 | T 5/9 (55.56%)	V 1/1 | NV 2/5 | T 3/6 (50.00%)
Cefepime	V 2/2 | NV 1/2 | T 3/4 (75.00%)	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 0/1 | NV 4/8 | T 4/9 (44.44%)	V 1/1 | NV 2/5 | T 3/6 (50.00%)
Ceftazidime	V 2/2 | NV 1/2 | T 3/4 (75.00%)	V 2/4 | NV 0/5 | T 2/9 (22.22%)	V 0/1 | NV 4/8 | T 4/9 (44.44%)	V 1/1 | NV 1/5 | T 2/6 (33.33%)
Cefoperazone	V 2/2 | NV 1/2 | T 3/4 (75.00%)	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 0/1 | NV 4/8 | T 4/9 (44.44%)	V 1/1 | NV 1/5 | T 2/6 (33.33%)
Cefoperazone/sulbactam	V 2/2 | NV 0/2 | T 2/4 (50.00%)	V 3/4 | NV 0/5 | T 3/9 (33.33%)	V 1/1 | NV 5/8 | T 6/9 (66.67%)	V 1/1 | NV 2/5 | T 3/6 (50.00%)
Amikacin	V 2/2 | NV 0/2 | T 2/4 (50.00%)	V 3/4 | NV 1/5 | T 4/9 (44.44%)	V 0/1 | NV 3/8 | T 3/9 (33.33%)	V 0/1 | NV 2/5 | T 2/6 (33.33%)
Gentamicin	V 2/2 | NV 0/2 | T 2/4 (50.00%)	V 3/4 | NV 1/5 | T 4/9 (44.44%)	V 0/1 | NV 3/8 | T 3/9 (33.33%)	V 0/1 | NV 3/5 | T 3/6 (50.00%)
Tobramycin	V 2/2 | NV 0/2 | T 2/4 (50.00%)	V 3/4 | NV 1/5 | T 4/9 (44.44%)	V 0/1 | NV 3/8 | T 3/9 (33.33%)	V 0/1 | NV 3/5 | T 3/6 (50.00%)
Netilmicin	V 2/2 | NV 0/2 | T 2/4 (50.00%)	V 3/4 | NV 1/5 | T 4/9 (44.44%)	V 0/1 | NV 3/8 | T 3/9 (33.33%)	V 0/1 | NV 3/5 | T 3/6 (50.00%)
Meropenem	V 1/2 | NV 0/2 | T 1/4 (25.00%)	V 2/4 | NV 1/5 | T 3/9 (33.33%)	V 0/1 | NV 2/8 | T 2/9 (22.22%)	V 0/1 | NV 3/5 | T 3/6 (50.00%)
Imipenem	V 2/2 | NV 0/2 | T 2/4 (50.00%)	V 1/4 | NV 1/5 | T 2/9 (22.22%)	V 1/1 | NV 2/8 | T 3/9 (33.33%)	V 0/1 | NV 2/5 | T 2/6 (33.33%)
Colistin	V 0/2 | NV 0/2 | T 0/4 (0.00%)	V 1/4 | NV 0/5 | T 1/9 (11.11%)	V 0/1 | NV 0/8 | T 0/9 (0.00%)	V 0/1 | NV 2/5 | T 2/6 (33.33%)
Polymyxin B	V 0/2 | NV 0/2 | T 0/4 (0.00%)	V 1/4 | NV 0/5 | T 1/9 (11.11%)	V 0/1 | NV 0/8 | T 0/9 (0.00%)	V 0/1 | NV 1/5 | T 1/6 (16.67%)

V = patients who developed VAP; NV = patients who did not develop VAP; T = total. Resistance is presented as resistant isolates/total isolates in each subgroup, followed by the overall resistance percentage.

Table 5: Antibiotic resistance pattern of Staphylococcus aureus isolated from endotracheal aspirate cultures

Antibiotic	Developed VAP (n=2)	No VAP (n=1)	Total isolates (n=3)
Ampicillin	2 (100.00%)	0 (0.00%)	2 (66.67%)
Amoxicillin/clavulanate	2 (100.00%)	0 (0.00%)	2 (66.67%)
Piperacillin	1 (50.00%)	0 (0.00%)	1 (33.33%)
Piperacillin/tazobactam	1 (50.00%)	0 (0.00%)	1 (33.33%)
Oxacillin	2 (100.00%)	0 (0.00%)	2 (66.67%)
Ceftriaxone/cefotaxime	2 (100.00%)	0 (0.00%)	2 (66.67%)
Cefepime	1 (50.00%)	0 (0.00%)	1 (33.33%)
Ceftazidime	1 (50.00%)	0 (0.00%)	1 (33.33%)
Cefoperazone	1 (50.00%)	0 (0.00%)	1 (33.33%)
Cefoperazone/sulbactam	1 (50.00%)	0 (0.00%)	1 (33.33%)
Netilmicin	1 (50.00%)	0 (0.00%)	1 (33.33%)
Vancomycin	0 (0.00%)	0 (0.00%)	0 (0.00%)

Linezolid	0 (0.00%)	0 (0.00%)	0 (0.00%)
Meropenem	0 (0.00%)	0 (0.00%)	0 (0.00%)
Imipenem	0 (0.00%)	0 (0.00%)	0 (0.00%)
Colistin	0 (0.00%)	0 (0.00%)	0 (0.00%)
Polymyxin B	0 (0.00%)	0 (0.00%)	0 (0.00%)

Table 6: ICU severity scores, expected length of stay and clinical outcomes according to VAP status

Parameter	Category	Developed VAP (n=10)	No VAP (n=60)	Overall (n=70)	Reported p-value
APACHE-IV	≤40	0 (0.00%)	1 (1.67%)	1 (1.43%)	0.0469
APACHE-IV	41–80	1 (10.00%)	10 (16.67%)	11 (15.71%)	
APACHE-IV	81–120	8 (80.00%)	43 (71.67%)	51 (72.86%)	
APACHE-IV	>120	1 (10.00%)	6 (10.00%)	7 (10.00%)	
APACHE-IV	Mean ± SD	100.80 ± 14.79	86.73 ± 21.07	97.31 ± 20.25*	
APS	≤60	0 (0.00%)	4 (6.67%)	4 (5.71%)	0.0050
APS	61–80	3 (30.00%)	15 (25.00%)	18 (25.71%)	
APS	81–100	3 (30.00%)	21 (35.00%)	24 (34.29%)	
APS	>100	4 (40.00%)	20 (33.33%)	24 (34.29%)	
APS	Mean ± SD	89.70 ± 15.69	90.18 ± 17.79	90.11 ± 17.40	
Expected LOS	≤5.0 days	0 (0.00%)	6 (10.00%)	6 (8.57%)	0.0309
Expected LOS	5.1–10.0 days	10 (100.00%)	51 (85.00%)	61 (87.14%)	
Expected LOS	10.1–15.0 days	0 (0.00%)	3 (5.00%)	3 (4.29%)	
Expected LOS	>15.0 days	0 (0.00%)	0 (0.00%)	0 (0.00%)	
Expected LOS	Mean ± SD (days)	7.67 ± 0.94	6.77 ± 1.23	6.89 ± 1.66	
Clinical outcome	Death	7 (70.00%)	17 (28.33%)	24 (34.29%)	0.0071
Clinical outcome	Outcome not known	1 (10.00%)	5 (8.33%)	6 (8.57%)	
Clinical outcome	Recovered	2 (20.00%)	38 (63.33%)	40 (57.14%)	
Total		10 (100.00%)	60 (100.00%)	70 (100.00%)	

DISCUSSION

The present prospective study evaluated 70 patients who underwent mechanical ventilation for more than 48 hours, of whom 10 (14.29%) developed ventilator-associated pneumonia (VAP). The observed incidence was comparatively lower than that reported by Charles et al. (2013), who conducted a prospective study involving 76 mechanically ventilated patients and found that 18 (23.70%) developed VAP, with an incidence density of 53.25 episodes per 1,000 ventilator-days. Their study also reported that 72.20% of VAP cases were early-onset and 27.80% were late-onset. In the present study, the majority of VAP patients were aged above 60 years (70.00%), while males constituted 80.00% of affected patients. Smoking and alcohol consumption for 16–30 years were each reported in 50.00% of VAP patients, although neither association was statistically significant (p=0.1979 and p=0.1632, respectively).[7]

Age and underlying clinical conditions are important considerations when evaluating patients who develop VAP. In the present study, 70.00% of patients with VAP were older than 60 years, compared with 43.33% of patients without VAP, while males accounted for 80.00% and 65.00% of the respective groups. However, age (p=0.3305) and sex (p=0.3499) showed no statistically significant association with VAP development. Similarly, chronic obstructive pulmonary disease was present in 30.00% of VAP patients, cerebrovascular accident in 40.00%, and diabetes mellitus in 20.00%. But et al. (2017), in a retrospective observational study involving 417 patients with VAP, reported a mean age of 69.9 ± 15.9 years, with males constituting 51.10% of patients. Their study identified coronary heart disease, unconsciousness at admission, steroid use and prolonged hospital stay as independent risk factors for mortality (p<0.01).[8]

The clinical presentation and indications for mechanical ventilation demonstrated important differences between patients with and without VAP in the present study. Fever was observed in 90.00% of VAP patients compared with 30.00% of non-VAP patients (p=0.0003), while cough lasting more than 30 days was reported in 50.00% and 20.00%, respectively (p=0.0245). Hypercapnia was present as an indication for intubation in 90.00% of VAP patients, compared with 53.33% of non-VAP patients. A Glasgow Coma Scale score of ≤8 was recorded in 30.00% of VAP patients and 16.67% of non-VAP patients, although this association was statistically non-significant (p=0.3803). Furthermore, bilateral pulmonary infiltrates were observed in 80.00% of patients following VAP development. Joseph et al. (2009), in a prospective study conducted over 15 months, reported that 58.30% of VAP episodes were late-onset and 41.70% were early-onset. They identified impaired consciousness, tracheostomy, re-intubation, emergency intubation and nasogastric tube placement as significant risk factors for VAP.[9]

The microbiological findings of the present study demonstrated a predominance of Gram-negative organisms among patients who developed VAP. Klebsiella pneumoniae was the most frequently isolated pathogen, accounting for 40.00% of VAP cases, followed by Acinetobacter baumannii and

Staphylococcus aureus (20.00% each), while Escherichia coli and Pseudomonas aeruginosa accounted for 10.00% each. All 10 VAP patients had positive endotracheal aspirate cultures, whereas 65.00% of patients without VAP had sterile cultures. Patil et al. (2017), in a prospective observational study involving 267 mechanically ventilated patients, reported VAP in 74 (27.71%) patients. Among 126 bacterial isolates recovered from patients with VAP, Klebsiella species accounted for 29 (23.02%) isolates, followed by Pseudomonas species in 27 (21.43%), Acinetobacter species in 24 (19.05%) and E. coli in 19 (15.08%). The investigators also reported that 55 (43.65%) isolates were multidrug-resistant. Although the organism percentages were calculated using different denominators, both studies demonstrated the important contribution of Gram-negative pathogens to VAP, with Klebsiella being particularly prominent in the present study.[10]

Antimicrobial resistance among Gram-negative organisms represented an important finding in the present study. Among A. baumannii isolates, resistance to piperacillin, ceftriaxone/cefotaxime, cefepime, ceftazidime and cefoperazone was observed in 75.00% of isolates, while resistance to meropenem and imipenem was 25.00% and 50.00%, respectively. No resistance to colistin or polymyxin B was reported in these isolates. K. pneumoniae demonstrated 44.44% resistance to aminoglycosides, while E. coli exhibited 66.67% resistance to cefoperazone/sulbactam and 55.56% resistance to ceftriaxone/cefotaxime. Among P. aeruginosa isolates, resistance to piperacillin, cefepime, gentamicin and meropenem was 50.00% each. Chaudhury et al. (2016), in a three-year study of 847 clinically suspected VAP cases, reported high antimicrobial resistance among non-fermenting Gram-negative bacilli, with resistance ranging from 40.00% to more than 80.00% for several antimicrobial agents. However, resistance to imipenem and polymyxin B was comparatively lower, at 33.10% and 2.40%, respectively.[11]

The antibiotic resistance profile of Staphylococcus aureus in the present study demonstrated substantial resistance to several beta-lactam antibiotics. Among three S. aureus isolates, resistance to ampicillin, amoxicillin/clavulanate, oxacillin and ceftriaxone/cefotaxime was observed in 66.67% of isolates for each antibiotic. Both S. aureus isolates recovered from patients with VAP were resistant to oxacillin, indicating methicillin resistance, whereas the isolate recovered from the non-VAP group showed no reported resistance. No resistance to vancomycin or linezolid was observed among the three isolates. Golia et al. (2013), in a retrospective study of early- and late-onset VAP, reported an overall VAP incidence of 35.14%, with 44.23% of cases classified as early-onset and 55.77% as late-onset. Their study found that all S. aureus isolates except one were methicillin-resistant. Additionally, multidrug-resistant P. aeruginosa and Acinetobacter species accounted for 40.00% and 37.50% of their respective isolates.[12]

The assessment of disease severity using the APACHE-IV and Acute Physiology Score (APS) systems demonstrated differences in the clinical characteristics of patients with and without VAP. In the present study, 80.00% of VAP patients had APACHE-IV scores between 81 and 120, compared with 71.67% of non-VAP patients. The mean APACHE-IV score was higher in the VAP group (100.80 ± 14.79) than in the non-VAP group (86.73 ± 21.07), with a reported p-value of 0.0469. The mean APS values were 89.70 ± 15.69 and 90.18 ± 17.79, respectively. The expected length of stay was also higher among patients who developed VAP (7.67 ± 0.94 days) compared with those without VAP (6.77 ± 1.23 days), with a reported p-value of 0.0309. Gupta et al. (2011), in a prospective cohort study involving 107 mechanically ventilated patients, reported a VAP incidence of 28.04% and found that higher APACHE-II scores were associated with increased VAP occurrence and mortality. They also reported mortality of 46.67% among VAP patients compared with 27.28% among non-VAP patients. The findings of both studies suggest an association between greater physiological severity and adverse clinical outcomes, although APACHE-II and APACHE-IV scores are not directly interchangeable.[13]

The clinical outcomes observed in the present study demonstrated considerably higher mortality among patients who developed VAP. Death occurred in 7 (70.00%) VAP patients compared with 17 (28.33%) patients without VAP, whereas recovery was recorded in 20.00% and 63.33%, respectively. Clinical outcomes were unknown in 10.00% of VAP patients and 8.33% of non-VAP patients. The association between VAP status and clinical outcome was statistically significant (reported p=0.0071). Mathai et al. (2016), in a prospective observational study involving mechanically ventilated ICU patients, reported that 95 (38.00%) developed VAP, with an incidence density of 40.1 infections per 1,000 ventilator-days. Their study demonstrated significantly longer ICU stays among VAP patients, with a median of 13 days compared with 6 days among non-VAP patients ($p<0.0001$). However, the mortality difference between VAP and non-VAP patients was not statistically significant (68.40% versus 61.30%; p=0.200). In contrast, the present study demonstrated a larger and statistically significant mortality difference between the two groups. These findings indicate that VAP was associated with poorer observed clinical outcomes in the present study, although the observational design and small number of VAP cases do not establish a causal relationship.[14]

CONCLUSION

The present study reported an incidence of ventilator-associated pneumonia (VAP) of 14.29% among 70 mechanically ventilated patients, with hypercapnia being the most common indication for intubation. Bilateral pneumonia was the predominant radiological finding, while Klebsiella pneumoniae was the most frequently isolated pathogen, followed by Acinetobacter baumannii and Staphylococcus aureus. The isolated organisms exhibited varying degrees of antimicrobial resistance, highlighting the importance of culture-guided antibiotic therapy. Patients developing VAP had higher mean APACHE-IV scores and significantly greater mortality (70.00%) compared with non-VAP patients (28.33%; p=0.0071).

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