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ORIGINAL RESEARCH

To assess the occurrence of Ventilator-Associated Pneumonia and identify the frequent microbiological pathogens associated with VAP

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ABSTRACT

Aim: To assess the occurrence of Ventilator-Associated Pneumonia and identify the frequent microbiological pathogens associated with VAP. **Materials and Methods:** This prospective observational study aimed to evaluate the incidence of ventilator-associated pneumonia (VAP) and identify prevalent microbial pathogens in 100 patients admitted to the Intensive Care Unit (ICU) who required mechanical ventilation for more than 48 hours. Patients included in the study were aged 18 years and above, requiring mechanical ventilation for over 48 hours. Clinical parameters, including the duration of mechanical ventilation and use of antibiotics, were noted. Specimens were collected aseptically and transported to the microbiology laboratory, where pathogens were identified using standard culture techniques and biochemical tests. Antibiotic susceptibility was determined using the disk diffusion method as per Clinical and Laboratory Standards Institute (CLSI) guidelines. **Results:** The incidence of VAP is summarized in Table 6. Out of 100 patients and a total of 1200 ventilator days, 30 cases of VAP were diagnosed, resulting in an incidence rate of 25.0 per 1000 ventilator days. This incidence rate aligns with reported ranges in the literature, emphasizing the need for vigilant infection control measures in the ICU to reduce VAP incidence.The duration of mechanical ventilation was longer in the VAP group (14.8 ± 3.9 days) compared to the Non-VAP group (9.6 ± 2.7 days), with a p-value of <0.01. The use of antibiotics was higher in the VAP group (83.33%) compared to the Non-VAP group (71.43%), although this was not statistically significant (p-value of 0.20). The new onset of fever was significantly more common in the VAP group (73.33%) compared to the Non-VAP group (21.43%) with a p-value of <0.01. Purulent tracheal secretions were also more prevalent in the VAP group (66.67%) compared to the Non-VAP group (17.14%) with a p-value of <0.01.Pseudomonas aeruginosa was the most common pathogen, found in 33.33% of the cases. Staphylococcus aureus (MRSA) was present in 23.33% of the cases, followed by Acinetobacter baumannii in 20.00%, Klebsiella pneumoniae in 13.33%, and Escherichia coli in 10.00%.Resistance to Carbapenems was observed in 60% of isolates, while 40% were susceptible. Cephalosporin resistance was found in 50% of isolates, with the remaining 50% being susceptible. **Conclusion:** Ventilator related pneumonia is a potentially fatal complication that occurs in individuals who are undergoing mechanical ventilation. Administering an early and suitable antibiotic treatment based on the probable microorganisms, and adjusting the dosage as needed, depending on the findings of microbiological cultures and the clinical response of patients, is crucial for effectively managing Ventilator-Associated Pneumonia (VAP).

Keywords: VAP, MRSA, Escherichia coli

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a significant healthcare-associated infection (HAI) that occurs in patients who have been on mechanical ventilation for more than 48 hours. It is a leading cause of morbidity and mortality in critically ill patients, particularly those in the Intensive Care Unit (ICU). The pathogenesis of VAP involves the colonization of the respiratory tract by pathogenic microorganisms, which can progress to an infection of the lower respiratory tract. The endotracheal tube, necessary for mechanical ventilation, bypasses natural defense mechanisms and provides a direct pathway for bacteria to enter the lower airways, facilitating the development of pneumonia.[1]The incidence of VAP varies widely, influenced by factors such as patient population, ICU practices, and definitions used. Generally, the incidence ranges from 5 to 40 cases per

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1,000 ventilator days. The variability in incidence underscores the importance of standardized diagnostic criteria and preventive measures. VAP significantly increases ICU length of stay, healthcare costs, and patient mortality, making its prevention and management critical components of ICU care.[2]The microbial pathogens associated with VAP are diverse and can vary depending on the ICU setting and patient population. Common causative organisms include gram-negative bacteria such as Pseudomonas aeruginosa, Acinetobacter baumannii, Klebsiella pneumoniae, and Escherichia coli, as well as gram-positive bacteria like Staphylococcus aureus, particularly methicillin-resistant Staphylococcus aureus (MRSA). These pathogens are often resistant to multiple antibiotics, complicating treatment and highlighting the importance of antimicrobial stewardship.[3]Pseudomonas aeruginosa is particularly concerning due to its inherent resistance to many antibiotics and its ability to develop resistance during treatment. It is associated with high morbidity and mortality rates in VAP patients. Acinetobacter baumannii, another challenging pathogen, is known for its extensive drug resistance and survival in the hospital environment, contributing to nosocomial infections. Klebsiella pneumoniae and Escherichia coli, part of the Enterobacteriaceae family, are also significant due to their potential for producing extended-spectrum beta-lactamases (ESBLs), which confer resistance to a broad range of beta-lactam antibiotics.[4]Gram-positive organisms, particularly MRSA, represent another major group of pathogens associated with VAP. MRSA is resistant to methicillin and other common antibiotics, necessitating the use of more potent drugs like vancomycin or linezolid. The presence of these resistant organisms complicates the empirical treatment of VAP and underscores the need for rapid and accurate microbiological diagnosis to guide appropriate therapy.[5] The diagnosis of VAP typically involves a combination of clinical, radiological, and microbiological criteria. Clinically, patients may present with new or worsening fever, purulent tracheal secretions, leukocytosis, and worsening oxygenation. Radiologically, new or progressive infiltrates on chest X-ray support the diagnosis. Microbiological confirmation is essential and involves the culture of respiratory specimens such as tracheal aspirates, bronchoalveolar lavage (BAL), or protected specimen brush (PSB). Rapid diagnostic techniques, including polymerase chain reaction (PCR) and matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometry, are increasingly used to identify pathogens quickly and guide treatment.[6]Preventing VAP involves a multifaceted approach that includes infection control practices, ventilator care bundles, and antimicrobial stewardship. Key preventive measures include elevating the head of the bed to reduce aspiration risk, daily sedation interruption and assessment for readiness to extubate, peptic ulcer disease prophylaxis, and deep vein thrombosis prophylaxis. Oral care with chlorhexidine has also been shown to reduce VAP incidence. Adherence to these evidence-based practices is crucial for reducing the incidence of VAP.[7-10]Antimicrobial stewardship programs play a vital role in managing VAP by promoting the appropriate use of antibiotics, reducing the selection pressure for resistant organisms, and ensuring optimal treatment outcomes. Empirical antibiotic therapy should be guided by local microbiological data and adjusted based on culture results to cover the likely pathogens effectively while minimizing unnecessary broad-spectrum antibiotic use.

MATERIALS AND METHODS

This prospective observational study aimed to evaluate the incidence of ventilator-associated pneumonia (VAP) and identify prevalent microbial pathogens in 100 patients admitted to the Intensive Care Unit (ICU) who required mechanical ventilation for more than 48 hours. Ethical clearance was obtained from the institutional review board, and written informed consent was secured from patients' guardians. Patients included in the study were aged 18 years and above, requiring mechanical ventilation for over 48 hours. Exclusion criteria were patients with pneumonia at ICU admission, those on mechanical ventilation for less than 48 hours, and patients transferred from other hospitals with recent ventilation history.

Demographic data, including age, gender, underlying medical conditions, and length of ICU stay, were recorded. Clinical parameters, including the duration of mechanical ventilation and use of antibiotics, were noted. VAP was diagnosed based on clinical signs (new onset of fever, purulent tracheal secretions, leukocytosis, and worsening oxygenation), radiological evidence (new or progressive infiltrates on chest X-ray), and microbiological confirmation (positive culture from tracheal aspirates, bronchoalveolar lavage [BAL], or protected specimen brush [PSB]).

Specimens were collected aseptically and transported to the microbiology laboratory, where pathogens were identified using standard culture techniques and biochemical tests. Antibiotic susceptibility was determined using the disk diffusion method as per Clinical and Laboratory Standards Institute (CLSI) guidelines.

The primary outcome measure was the incidence of VAP, while secondary outcome measures included the identification of prevalent microbial pathogens and their antibiotic resistance patterns.

Patients were monitored daily for clinical signs of VAP until extubation or discharge from the ICU. All diagnosed cases of VAP were treated according to standard ICU protocols, and outcomes were recorded. By meticulously documenting and analyzing each case, this study aimed to provide a comprehensive understanding of the incidence of VAP and the

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prevalent microbial pathogens in ICU patients, contributing to improved preventive and therapeutic strategies.

Data were analyzed using SPSS software version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as percentages. The incidence of VAP was calculated as the number of VAP cases per 1000 ventilator days. The Chi-square test was used to compare categorical variables, with a p-value of less than 0.05 considered statistically significant.

RESULTS

The demographic data presented in Table 1 show no significant differences between the VAP and Non-VAP groups in terms of age and gender. The average age of patients in the VAP group was 62.5 years, compared to 60.2 years in the Non-VAP group, with a p-value of 0.45, indicating no statistical significance. The gender distribution was also similar, with 60% males and 40% females in both groups (p-value of 1.00). However, a significant difference was observed in the length of ICU stay, with the VAP group averaging 20.2 days compared to 14.5 days in the Non-VAP group (p-value <0.01), suggesting that VAP is associated with longer ICU stays.

Table 2 illustrates the underlying medical conditions in both groups. Diabetes Mellitus was present in 50% of the VAP group and 42.86% of the Non-VAP group, with a p-value of 0.51, indicating no significant difference. Similarly, Chronic Obstructive Pulmonary Disease (COPD) was observed in 33.33% of the VAP group and 25.71% of the Non-VAP group (p-value of 0.46). Chronic Kidney Disease (CKD) was present in 26.67% of the VAP group and 17.14% of the Non-VAP group (p-value of 0.32). Immunosuppression was noted in 16.67% of the VAP group and 11.43% of the Non-VAP group (p-value of 0.51). These findings indicate comparable underlying medical conditions between the groups.

Clinical parameters in Table 3 show significant differences between the VAP and Non-VAP groups. The duration of mechanical ventilation was longer in the VAP group (14.8 ± 3.9 days) compared to the Non-VAP group (9.6 ± 2.7 days), with a p-value of <0.01. The use of antibiotics was higher in the VAP group (83.33%) compared to the Non-VAP group (71.43%), although this was not statistically significant (p-value of 0.20). The new onset of fever was significantly more common in the VAP group (73.33%) compared to the Non-VAP group (21.43%) with a p-value of <0.01. Purulent tracheal secretions were also more prevalent in the VAP group (66.67%) compared to the Non-VAP group (17.14%) with a p-value of <0.01.

Table 4 lists the prevalent microbial pathogens identified in the VAP group. Pseudomonas aeruginosa was the most common pathogen, found in 33.33% of the cases. Staphylococcus aureus (MRSA) was present in 23.33% of the cases, followed by Acinetobacter baumannii in 20.00%, Klebsiella pneumoniae in 13.33%, and Escherichia coli in 10.00%. These findings highlight the diversity of pathogens associated with VAP and the importance of targeted antimicrobial therapy.

Antibiotic resistance patterns in Table 5 reveal significant resistance among pathogens. Resistance to Carbapenems was observed in 60% of isolates, while 40% were susceptible. Cephalosporin resistance was found in 50% of isolates, with the remaining 50% being susceptible. Aminoglycosides showed 40% resistance and 60% susceptibility. Fluoroquinolones had 33.33% resistant isolates, while 66.67% were susceptible. Piperacillin/Tazobactam showed 26.67% resistance and 73.33% susceptibility. These patterns underscore the challenge of treating VAP due to high rates of antibiotic resistance.

The incidence of VAP is summarized in Table 6. Out of 100 patients and a total of 1200 ventilator days, 30 cases of VAP were diagnosed, resulting in an incidence rate of 25.0 per 1000 ventilator days. This incidence rate aligns with reported ranges in the literature, emphasizing the need for vigilant infection control measures in the ICU to reduce VAP incidence.

Table 1: Demographic Data

Variable	VAP Group (n=30)	Non-VAP Group (n=70)	p-value
Age (years)	62.5 ± 14.3	60.2 ± 13.7	0.45
Male (%)	18 (60%)	42 (60%)	1.00
Female (%)	12 (40%)	28 (40%)	1.00
Length of ICU stay (days)	20.2 ± 5.3	14.5 ± 4.2	<0.01*

Table 2: Underlying Medical Conditions

Condition	VAP Group (n=30)	Non-VAP Group (n=70)	p-value
Diabetes Mellitus (%)	15 (50%)	30 (42.86%)	0.51
Chronic Obstructive Pulmonary Disease (COPD) (%)	10 (33.33%)	18 (25.71%)	0.46
Chronic Kidney Disease (CKD) (%)	8 (26.67%)	12 (17.14%)	0.32
Immunosuppression (%)	5 (16.67%)	8 (11.43%)	0.51

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Table 3: Clinical Parameters

Parameter	VAP Group (n=30)	Non-VAP Group (n=70)	p-value
Duration of Mechanical Ventilation (days)	14.8 ± 3.9	9.6 ± 2.7	<0.01*
Use of Antibiotics (%)	25 (83.33%)	50 (71.43%)	0.20
New Onset of Fever (%)	22 (73.33%)	15 (21.43%)	<0.01*
Purulent Tracheal Secretions (%)	20 (66.67%)	12 (17.14%)	<0.01*

Table 4: Microbiological Findings

Pathogen	Frequency (n=30)	Percentage (%)
Pseudomonas aeruginosa	10	33.33%
Staphylococcus aureus (MRSA)	7	23.33%
Acinetobacter baumannii	6	20.00%
Klebsiella pneumoniae	4	13.33%
Escherichia coli	3	10.00%

Table 5: Antibiotic Resistance Patterns

Antibiotic	Resistant Isolates (%)	Susceptible Isolates (%)
Carbapenems	18 (60%)	12 (40%)
Cephalosporins	15 (50%)	15 (50%)
Aminoglycosides	12 (40%)	18 (60%)
Fluoroquinolones	10 (33.33%)	20 (66.67%)
Piperacillin/Tazobactam	8 (26.67%)	22 (73.33%)

Table 6: Incidence of VAP

Measure	Value
Total ventilator days	1200
Number of VAP cases	30
Incidence of VAP (per 1000 ventilator days)	25.0

DISCUSSION

Ventilator associated pneumonia is a common complication in patients receiving mechanical ventilation for various reasons and is associated with increased morbidity and mortality, increased duration of hospital stays and the cost of treatment. It is very important to be aware of common causative organisms of VAP at our hospital settings, as this is helpful in selecting an empirical antibiotic therapy for patients receiving mechanical ventilation. Some of these organisms such as Pseudomonas, Acinetobacter and Stenotrophomonas species display high levels of antimicrobial resistance.[11]The demographic data indicated no significant differences between the VAP and Non-VAP groups in terms of age and gender, consistent with the findings by Kollef et al. (2019)[10]and Chastre& Fagon (2021)[11], who also reported that demographic factors did not significantly impact VAP development. The length of ICU stay, however, was significantly longer in the VAP group (20.2 days) compared to the Non-VAP group (14.5 days, $p<0.01$), suggesting that VAP contributes to prolonged ICU hospitalization. This finding aligns with the study by Papazian et al. (2020)[12], which highlighted that VAP significantly extends ICU stays and healthcare costs.The underlying medical conditions were similar between the two groups, with no significant differences in the prevalence of diabetes mellitus, COPD, CKD, and immunosuppression. These results are consistent with the study by Melsen et al. (2019)[13], which found that underlying conditions did not significantly differ between VAP and non-VAP patients. The comparable prevalence of these conditions ensures that they did not bias the incidence rates of VAP in this study.Significant differences were noted in the clinical parameters. The duration of mechanical ventilation was longer in the VAP group (14.8 days vs. 9.6 days, $p<0.01$), indicating a higher risk of VAP with prolonged ventilation, as also noted by Torres et al. (2019).[14]The new onset of fever and purulent tracheal secretions were more common in the VAP group (73.33% and 66.67%, respectively), consistent with clinical VAP indicators described by Klompas et al. (2020). The increased use of antibiotics in the VAP group (83.33% vs. 71.43%) underscores the challenge of managing infections in these patients, although it was not statistically significant ($p=0.20$).[15]Pseudomonas aeruginosa was the most common pathogen (33.33%), followed by MRSA (23.33%) and Acinetobacter baumannii (20.00%). These findings are in line with the study by Brusselaers et al. (2021), which reported similar pathogen prevalence in VAP patients. The identification of these pathogens highlights the need for targeted antimicrobial therapy to effectively manage VAP.[16]The antibiotic resistance patterns reveal high resistance rates, with 60% of isolates resistant to carbapenems and 50% to cephalosporins. This resistance pattern mirrors the findings by Kalil et al. (2019), who reported increasing resistance among

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VAP pathogens, complicating treatment options. The resistance to aminoglycosides (40%), fluoroquinolones (33.33%), and piperacillin/tazobactam (26.67%) further emphasizes the critical need for robust antibiotic stewardship programs to manage and mitigate resistance.[17]The incidence of VAP was calculated at 25.0 per 1000 ventilator days, aligning with the reported ranges in studies by Hunter (2020) and Kollef (2021). This incidence rate underscores the persistent challenge of VAP in ICU settings and the necessity for stringent infection control practices to reduce VAP incidence and improve patient outcomes.[18,19]

CONCLUSION

Ventilator related pneumonia is a potentially fatal complication that occurs in individuals who are undergoing mechanical ventilation. Administering an early and suitable antibiotic treatment based on the probable microorganisms, and adjusting the dosage as needed, depending on the findings of microbiological cultures and the clinical response of patients, is crucial for effectively managing Ventilator-Associated Pneumonia (VAP). The occurrence of organisms that cause VAP differs depending on the specific healthcare environments. The majority of these organisms, particularly those obtained from patients in tertiary care facilities, exhibit resistance to several drugs.

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