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ORIGINAL ARTICLE

Prevalence of ventilator-associated events and antibiogram of bacterial isolates of ventilator-associated pneumonia in a tertiary care hospital of Uttarakhand

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ABSTRACT

Background and Objectives: Despite progress in diagnosing and managing ventilator-associated pneumonia (VAP), ongoing monitoring of ventilator-associated events (VAE) is crucial due to VAP's persistent prominence as the primary cause of Hospital-Acquired Infection (HAI) among Intensive Care unit patients. This study was done to illuminate the prevalence of VAE and antibiogram of bacterial isolates of VAP in a tertiary care hospital of Uttarakhand.

Materials and Methods: This cross-sectional study focused on ICU patients. Adult patients ventilated for > 2 days were monitored daily, with VAE data analyzed using Center of Disease Control & Prevention (CDC) criteria. Specimens were sent to the Microbiology Department and cultured on Blood agar and MacConkey agar. Identification and antimicrobial profiles of isolates were determined using Vitek-2 Compact.

Results: 1220 ventilated individuals were assessed in total. VAE was diagnosed in 6.4% (78/1220) of the patients, the same later developed ventilator associated condition (VAC), 74 developed the infection-related VAC (IVAC), and 60 developed the possible/probable VAP (PVAP) among the 78 VAE cases. *Klebsiella pneumoniae* (35%), *Acinetobacter baumannii* (33%), and *Pseudomonas aeruginosa* (16%) were the most common isolated organisms. Colistin (57%) was the most effective against *Klebsiella pneumoniae*, followed by amikacin (28.5%) and trimethoprim+sulfamethoxazole (24%). *Pseudomonas aeruginosa* was most susceptible to imipenem (70%), meropenem, cefoperazone+sulbactam, and colistin (60%). *Acinetobacter baumannii* was most susceptible to colistin (85%), tigecycline (65%), and trimethoprim+sulfamethoxazole (25%).

Conclusion: The most common cause of HAI is VAP. The purpose of this study is to determine the importance of starting suitable antibiotics early for prognosis and the difficulty of diagnosing VAP.

Keywords: Ventilator; *Klebsiella pneumonia*; *Acinetobacter baumannii*; *Pseudomonas aeruginosa*

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INTRODUCTION

Intensive Care Units (ICU) acquired pneumonia encompasses Ventilator-associated Pneumonia (VAP), which is defined as an infection of the lung tissue in patients who have undergone invasive mechanical ventilation for a minimum duration of 48 hours (1).

The development of VAP is heavily influenced by interactions among the endotracheal tube, risk factors, invasive bacteria aggressiveness, and host immunity. The main risk factor is the presence of an endotracheal tube, disrupting natural defenses and promoting micro-aspiration. Factors like intubation, bacterial biofilm in the tube, secretion pooling, impaired mucociliary clearance, and biofilm growth allow infectious bacteria to access the lower respiratory tract (2, 3).

In 2013, the Centers for Disease Control (CDC) introduced a new method for tracking the complications associated with the utilization of ventilator support in mechanically ventilated patients (4). This replaces CDC's previous definitions of VAP by Ventilator-Associated Events (VAE). As a result, VAE definitions were created to make surveillance more objective and repeatable, to make automation easier, and to broaden the scope of safety surveillance to include any event that is severe enough to necessitate an ongoing increase in ventilator support (5).

The ventilator-associated condition (VAC), the infection-related VAC (IVAC), and the possible/probable VAP (PVAP) are the three levels of this algorithm's surveillance targets (6).

The new National Health Safety Network (NHSN) surveillance criteria are only intended for surveillance and are not intended for clinical patient management. Most nosocomial infections seen in ICU are respiratory infections. In large, multicenter research conducted around the world, 50% of the patients had an infection when they were being observed (7).

This study was conducted to evaluate the occurrence of VAE in patients on mechanical ventilation and to analyze the antimicrobial sensitivity pattern of Bacterial isolates of VAP in the ICU of a tertiary care hospital of Uttarakhand using the surveillance criteria given by the CDC in 2013.

MATERIALS AND METHODS

This cross-sectional study was carried out at the Department of Microbiology of Shri Guru Ram Rai Institute of Medical & Health Sciences, Shri Mahant Indresh Hospital over a one-year period, from July 2020 to June 2021. This study was approved by the Institutional Research and ethical committee and written informed consent was taken from attendants of the patients included in the study.

Inclusion criteria. All adult patients over the age of 18 years on mechanical ventilation for > 2 days in different ICUs were followed daily, and VAE data were collected using the checklist obtained from the CDC website.

Exclusion criteria.

1. Age <18 years.
2. Patients diagnosed with pneumonia before mechanical ventilation or within 48 hours of mechanical ventilation.
3. On admission, patients who were diagnosed with lower respiratory infections such as pulmonary tuberculosis, chronic obstructive pulmonary disease, acute respiratory distress syndrome, or bronchial asthma.
4. Severely immunocompromised patients, including those diagnosed with Acquired Immune Deficiency Syndrome (AIDS), organ transplant recipient, cancer patients in their terminal stages.
5. Patients already under VAE surveillance were excluded.

Data collection. A total of 1220 ventilated patients were evaluated during the course of the study. Different specimens like Endotracheal aspirates, Suction tip secretion, etc. were collected from all the mechanically ventilated patients from various ICUs like Medical ICU (MICU), Surgical ICU (SICU), Respiratory ICU (RICU) and Critical Care Unit (CCU). VAE were identified using the new NHSN, VAE surveillance algorithm as follows: (4).

VAC. It is characterized by a rise in the minimum positive end expiratory pressure (PEEP) by at least 3 cm H_2O for a minimum of 2 days, or an increase of at least 20 points in the daily minimum fraction of inspired oxygen (FiO_2) over the course of 2 days.

IVAC. It is characterized by the presence of at least one of the following four conditions: fever, hypothermia, leukocytosis, or leukopenia, along with the initi-

ation of a new antimicrobial agent that is maintained for ≥4 days.

PVAP. It is characterized by the detection of a significant amount of a pneumonia-causing pathogen from respiratory samples, including tracheal aspirate, Broncho alveolar lavage, and sputum.

Sample processing. Specimens were cultured on Blood agar and MacConkey agar and incubated aerobically at 37°C for 16-18 hours. The plates were examined for bacterial growth if the growth is ≥ 10^5 CFU/ml, then, identification and antimicrobial susceptibility testing were done by Vitek-2 Compact (bioMerieux).

Statistical analysis. The data were collected and entered in MS- Excel 2010 and statistical analysis was done using the SPSS software version 22.0 for Windows. Any association between categorical variables has been calculated via non-parametric test viz chi-square test. P- value <0.05 was considered significant. The data mainly consists of numerical values and percentages.

RESULTS

Out of 1220 intubated cases in ICU in which 78 patients had developed VAE (6.4%). The VAE patients were reviewed for demographic (age, sex) data, clinical and laboratory data were also collected. Out of the total patients with VAE, 64/78 (82%) were male and 14/78 (18%) were female. There is no significant correlation between gender and VAE (Table 1).

Out of total cases, 78 cases were of VAC, 74 patients meet the criteria of IVAC and 60 patients meet the criteria of PVAP (Table 2).

Out of 78 identified cases, most cases were belong to the age group of 41-60 years (41%) followed by 61-80 years (34.6%) age group. There is no significant correlation between age group and VAE (Table 3).

A total of 60 samples were collected from the patients going to VAP, out of which Suction tip secretion (78.4%) were maximum followed by endotracheal aspirates (20%) (Table 4).

The highest number of VAP patients was reported from MICU i.e., 43/60 (71.7%) followed by SICU i.e., 13/60 (21.7), RICU i.e., 3/60 (5%) and CCU i.e., 1/60 (1.7%) (Fig.1).

Table 1. Percentage positivity for VAE (n=1220)

Total number of patients	Positive for VAE (%) (n=78)	Negative for VAE (%) (n=1220)	p-value
Male	64 (82%)	953 (83.4%)	
Female	14 (18%)	189 (16.6%)	0.748
Total	78	1142	

*p value was statistically significant if <0.05

Table 2. Breakup of VAE among ICU patients (n=78)

	No. of Patients
VAC	78
VAC + I-VAC	74
VAC + I-VAC + PVAP	60

Table 3. Age wise distribution of VAE patients (n=78)

Age Group (in years)	Patients with VAE (n=78) 5 (6.4%)	Total number of patients (n=1220)	p-value
<20	14 (18%)	80 (6.6%)	
21-40	32 (41%)	238 (19.5%)	
41-60	27 (34.6%)	481 (39.4%)	0.142
61-80		421 (34.5%)	

*p value was statistically significant if <0.05

Table 4. Sample distribution among patients going into VAP (n=60)

S. no.	Samples Endotracheal	Number (%)
1.	aspirates Suction tip	12 (20)
2.	secretion	47 (78.4)
3.	Trans tracheal tip secretion	1 (1.6)
Total		60

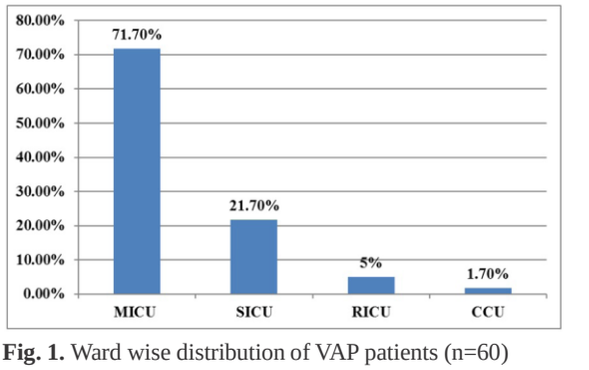

Fig. 1. Ward wise distribution of VAP patients (n=60)

Culture sensitivity of specimens using standard microbiological methods revealed that most common organism isolated was *Klebsiella pneumoniae* i.e., 21/60 (35%) followed by *Acinetobacter baumannii* i.e., 20/60 (33%) and *Pseudomonas aeruginosa* i.e., 10/60 (17%) (Fig. 2).

As shown in Fig. 3 *Klebsiella pneumoniae* showed maximum sensitivity towards colistin (57%) followed by amikacin (28.5%) and cotrimoxazole (24%).

As per Fig. 4, *Acinetobacter baumannii* showed maximum sensitivity towards colistin (85%) followed by tigecycline (65%) and cotrimoxazole (25%).

As per Fig. 5, *Pseudomonas aeruginosa* showed maximum sensitivity towards imipenem (70%) & meropenem and cefoperazone+sulbactam and colistin (60%).

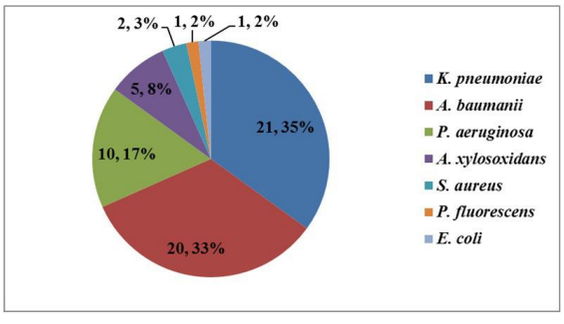

Fig. 2. Distribution of various VAP isolates (n= 60)

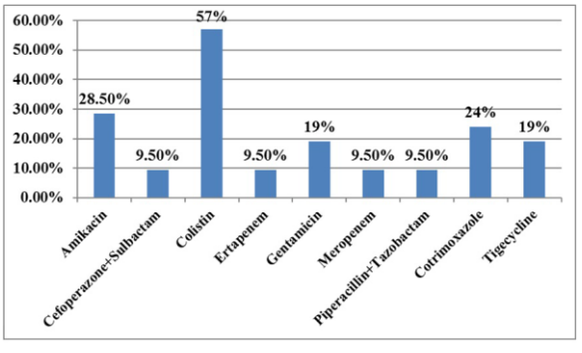

Fig. 3. Antimicrobial Sensitivity Pattern of *Klebsiella pneumoniae* (n=21).

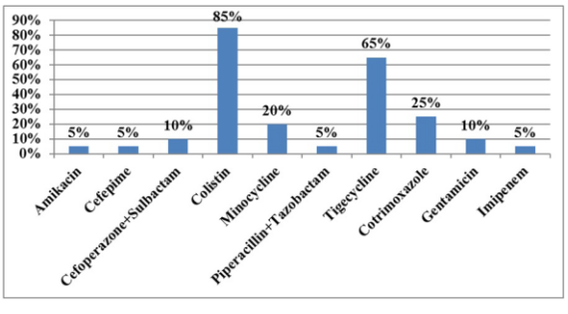

Fig. 4. Antimicrobial sensitivity pattern of *Acinetobacter baumannii* (n=20)

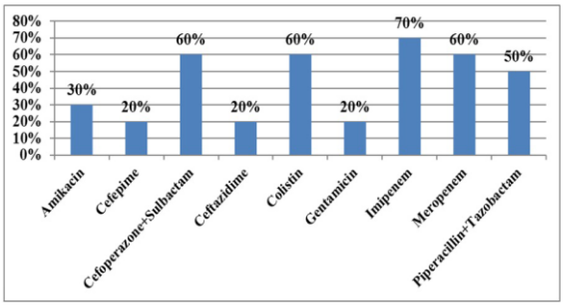

Fig. 5. Antimicrobial sensitivity pattern of *Pseudomonas aeruginosa* (N=10)

DISCUSSION

The NHSN changed surveillance method from VAP to VAE in 2013. VAE is a new method for monitoring complications in patients on mechanical ventilation. Recent studies are beginning to provide information on the most effective methods for preventing VAEs and have confirmed that there is a strong correlation between VAEs and adverse outcomes. However, VAE definitions also have their own shortcomings (4).

VAE is the new definition for surveillance. It has been noticed that this VAE surveillance system can identify a few cases of VAP, despite shifting the focus from pneumonia to the other non-infectious condition. VAC only includes events in which the respiratory condition deteriorates. IVAC includes all events in which infection worsens respiratory symptoms but does not include microbiological confirmation, whereas PVAP encompasses all IVAC events that have been confirmed by microbiological diagnosis or confirmation. The chest X-ray, employed for radiological VAP diagnosis, is not used in the VAE criteria for identifying VAP. As a result, patients who exhibit clinical and radiological similarities to VAP but do not satisfy the VAE criteria regarding stable baseline ventilator settings or deteriorating gas exchange are not eligible. In addition, only IVACs can be identified if a respiratory sample is not sent to the laboratory for culture (microbiological confirmation is not performed), but the presence of PVAP in these infection-related cases might go unnoticed. Therefore, the new VAE surveillance definition may have

missed some VAP cases (4, 5, 8).

The incidence of VAE in present study was 6.4%, which is much lesser then the studies conducted by Sharma et al. and Thomas A et al. where VAE incidence was 19.5% and 15.1% respectively (8, 9). Possibly, the higher incidence is due to a lower number of patients enrolled, which is found similar to the research conducted by Thomas A et al. where the occurrence of VAE was elevated among males compared to females, specifically at a rate of 80%, aligning with the findings of the present study with 82% male patients (9).

In this study, the maximum number of VAE cases found in the age group of 41-60 years (41%). In contrast, a study conducted in Kerala found that 42.5% of cases were in the 51-65 years age group (10).

We found a higher incidence of VAP cases (71.07%) in the MICU compared to other ICUs. The predominant risk factors for VAP among MICU patients included reduced consciousness levels, immunosuppression, prolonged usage of antibiotics, coma, pre-existing lung conditions,, neurological diseases, and the need for reintubation (8).

VAP is usually characterized as a polymicrobial infection, however, in our study, it is found to be only monomicrobial VAP infection which differs with the results of other studies (11, 12).

The most common organisms isolated were *Klebsiella pneumoniae* (35%) followed by *Acinetobacter baumannii* (33%) and *Pseudomonas aeruginosa* (17%). Likewise, in a study undertaken by Shagufta Jahoor et al. the predominant bacteria identified were *Klebsiella pneumoniae* (38.3%), succeeded by *Acinetobacter baumannii* (21.7%) and *Pseudomonas aeruginosa* (16.6%) (13).

Other studies results have also identified *Klebsiella pneumoniae* as the most common microorganism in VAP, likely attributed to its production of carbapenemases and various other virulence factors. While most of the studies have determined *Acinetobacter baumannii* as the most common isolate of VAP, this could be attributed to its production of virulence factors such as universal stress protein A and phospholipase D (14-19).

Airway intubation is associated with increased frequency of Gram-negative bacterial colonization of upper and lower respiratory tract with subsequent overgrowth and pneumonia (20).

In our study, *Klebsiella pneumoniae* has the highest sensitivity towards colistin (57%) and amikacin (28.5%) which can be compared to the study of Mallick et al. (21), *Acinetobacter baumannii* showed highest sensitivity towards colistin (85%) and tigecycline (65%) quite comparable with the study of Patro S. et al. (22). Like the findings of Joseph et al. and Day et al., *Pseudomonas aeruginosa* showed sensitivity to imipenem (70%) followed by meropenem (60%) and piperacillin+tazobactam (50%) (11, 23).

CONCLUSION

In conclusion, this study focused on the prevalence of VAE, along with bacteria associated and their antimicrobial susceptibility of bacterial isolates in VAP cases within a tertiary care hospital in Uttarakhand. The transition from VAP to VAE surveillance marked a significant change, with VAE definitions aiming for more objective and repeatable monitoring. The incidence of VAEs observed was 6.4%, lower than in other studies.

Monomicrobial VAP was a notable finding in this study, diverging from the typical polymicrobial nature. The most frequently isolated bacteria were *Klebsiella pneumoniae* (35%), *Acinetobacter baumannii* (33%), and *Pseudomonas aeruginosa* (17%). Sensitivity patterns revealed colistin and amikacin as effective treatments for *Klebsiella pneumoniae*, while colistin and tigecycline demonstrated efficacy against *Acinetobacter baumannii*. *Pseudomonas aeruginosa* exhibited sensitivity to imipenem, meropenem, and piperacillin+tazobactam.

It is important to acknowledge the limitations of the new VAE surveillance method, as some cases of VAP might be missed due to altered criteria. The study underscores the complex nature of VAP development, influenced by endotracheal tube presence, risk factors, bacterial virulence, and host immunity. The insights gained from this study contribute to the understanding of VAEs and their management in the context of a tertiary care hospital setting. Further investigations are necessary to refine surveillance strategies and treatment approaches for VAP and related conditions.

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