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Antimicrobial resistance patterns in ventilator-associated pneumonia (VAP) in ICU Patients

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Abstract
Introduction and Background: A serious nosocomial infection known as ventilator-associated pneumonia (VAP) strikes severely sick patients in intensive care units (ICUs). The rise in healthcare expenses, morbidity, and mortality rates is mostly attributable to the prevalence of multidrug-resistant (MDR) infections. Effective antibiotic stewardship and patient care require an understanding of the patterns of antimicrobial resistance (AMR) in VAP. The purpose of this research is to help direct empirical treatment and infection control efforts by analyzing the resistance profiles of bacterial isolates in patients with VAP.
Material and Methods: This prospective observational study included 60 patients with a clinical and microbiological diagnosis of VAP and was carried out in the intensive care unit of a tertiary care institution. This study was conducted at the Department of Microbiology, Mamata Medical Collage, Khammam, Telangana, India from December 2018 to November 2019. The etiological agents were determined by collecting and cultureing bronchoalveolar lavage (BAL) and endotracheal aspirates. Followed CLSI protocols for antimicrobial susceptibility testing, which included the Kirby-Bauer disk diffusion method and MIC determination. Multiple drug-resistant (MDR), extensively drug-resistant (XDR), and pan-drug-resistant (PDR) isolates were studied for their prevalence.
Results: The study found that out of 60 patients, the most prevalent pathogens were Escherichia coli (10%), Acinetobacter baumannii (20%), Pseudomonas aeruginosa (25%), and Klebsiella pneumoniae (35%). Acinetobacter baumannii (85%) and Klebsiella pneumoniae (78%) exhibited resistance to carbapenems, cephalosporins, and aminoglycosides, indicating a significant incidence of multidrug-resistant organisms. For 70% of the multidrug-resistant strains, colistine and tigecycline still worked. A total of 40% of VAP patients died, with a considerably greater death rate (60%, $p<0.05$) in patients infected with multidrug-resistant bacteria.
Conclusion: This study shows that VAP cases have an alarmingly high risk of antibiotic resistance, which calls for new treatment approaches, stringent infection control measures, and antimicrobial stewardship programs. In order to decrease mortality and morbidity caused by VAP, it is crucial to identify resistant pathogens early on and utilize antibiotics wisely.

Keywords: Ventilator-associated pneumonia, antimicrobial resistance, ICU, Multidrug-resistant pathogens

Introduction
One of the most prevalent and dangerous healthcare-associated infections (HAIs) in intensive care units (ICUs) is ventilator-associated pneumonia (VAP). Pneumonia that develops at least 48 hours following endotracheal intubation and mechanical breathing is characterized as post-operative pneumonia. Especially when caused by MDR bacteria, VAP is linked to higher rates of mortality, longer hospital admissions, and more morbidity. Factors such as local patterns of antibiotic resistance, patient demographics, and underlying health conditions have a significant impact on the prevalence of ventilator-associated pneumonia (VAP) [1-3].

In severely sick patients, compromised host defense mechanisms contribute to the pathophysiology of ventilator-associated pneumonia (VAP), which also includes aspiration of oropharyngeal or stomach secretions into the lower respiratory tract and biofilm development on the endotracheal tube. Prolonged mechanical breathing, previous antibiotic exposure, immunosuppression, chronic comorbidities (such as diabetes, COPD, and renal failure), and invasive medical procedures are some of the risk factors that might lead to ventilator-associated pneumonia (VAP) [3-5].

The development of antimicrobial resistance (AMR) in the bacteria that cause VAP is a big

problem for those who deal with its care. Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii, Escherichia coli, Staphylococcus aureus, and Enterobacter species are a few of the most often implicated organisms. Some of these infections have developed resistance to antibiotics that cover a wide range of symptoms and infections, including carbapenems, cephalosporins, aminoglycosides, and fluoroquinolones. Treatment choices are further complicated by the widespread incidence of multidrug-resistant (MDR), extensively drug-resistant (XDR), and pan-drug-resistant (PDR) bacteria, which often need the use of antibiotics like tigecycline and colistin as last resorts [4-6].

Antimicrobial stewardship initiatives, stringent infection control measures, and constant monitoring of local resistance patterns are all necessary to combat the growing problem of antibiotic resistance in intensive care units. To improve clinical outcomes in VAP patients, it is necessary to administer empirical antibiotic therapy early and appropriately using local antibiograms [5-7].

Patients hospitalized with ventilator-associated pneumonia (VAP) will have their antibiotic resistance patterns studied. Ultimately, this research aims to improve patient management and reduce mortality rates by identifying the most common bacterial pathogens and their resistance profiles. This will help with empirical treatment strategies, antimicrobial stewardship, and infection control measures [8-10].

Materials and Methods

The tertiary care hospital's intensive care unit (ICU) was the setting for this prospective observational study, which ran for a predetermined amount of time. This study was conducted at the Department of Microbiology, Mamata Medical Collage, Khammam, Telangana, India from December 2018 to November 2019. Patients with ventilator-associated pneumonia (VAP) as determined by microbiological and clinical criteria were included in the study. After obtaining informed consent from patients' legal guardians, the Institutional Ethics Committee gave their ethical clearance.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients on mechanical ventilation for more than 48 hours.
- Diagnosed cases of VAP based on clinical signs, including fever (≥38°C), leukocytosis
- Positive microbiological cultures from endotracheal aspirates

Exclusion Criteria

- Patients with pneumonia prior to ICU admission
- Patients who received antibiotics for more than 72 hours before ICU admission.
- Patients with underlying lung diseases such as tuberculosis, interstitial lung disease
- Patients with incomplete medical records

Microbiological Analysis:

Patients who were thought to have ventilator-associated pneumonia (VAP) had endotracheal aspirates and blood samples taken aseptically. Gram staining, culture, and biochemical testing were used at the microbiology laboratory to identify the bacteria in the sample. The Kirby-Bauer disk diffusion method and minimum inhibitory concentration (MIC) determination were used for antimicrobial susceptibility testing in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines. It was noted that there were strains that were resistant to multiple drugs, to a wide range of drugs, and to pan-drug resistance.

Statistical Analysis

Statistical software was used for data analysis. Mean ± standard deviation was used to display continuous variables, whereas percentages were used for categorical variables. To compare proportions, either Fisher's exact or chi-square tests were utilized, and a p-value less than 0.05 was deemed statistically significant.

Results

Study participants included sixty individuals with a ventilator-associated pneumonia (VAP) diagnosis. An analysis was conducted on the demographic distribution, microorganisms responsible, trends of antibiotic resistance, and patient outcomes.

Table 1: Demographic and Clinical Characteristics of VAP Patients

Parameter	Number of Patients (n=60)	Percentage (%)
Age (Mean ± SD)	58.3 ± 12.7 years	—
Gender (Male/Female)	38 / 22	63.3 / 36.7
Duration of Ventilation (>7 days)	45	75
Comorbidities		
Diabetes Mellitus	20	33.3
Hypertension	18	30.0
Chronic Kidney Disease	12	20.0
Immunosuppression	10	16.7
Prior Antibiotic Use	40	66.7
Mortality Rate	24	40.0

Table 1 provides a concise overview of the patient demographics and clinical features associated with VAP. With an average age of 58.3 years, the majority were men (63.3%). Comorbidities such as diabetes (33.3%) and hypertension (30%) were frequent, and mechanical ventilation was needed for more than seven days by 75% of patients. Antibiotic usage in the past was found in 66.7% of cases, suggesting that it may have played a role in the rise of MDR-pathogens.

Table 2: Distribution of Bacterial Pathogens Isolated from VAP Patients

Bacterial Isolate	Number of Isolates (n=60)	Percentage (%)
Klebsiella pneumoniae	21	35.0
Pseudomonas aeruginosa	15	25.0
Acinetobacter baumannii	12	20.0
Escherichia coli	6	10.0
Staphylococcus aureus	4	6.7
Enterobacter spp.	2	3.3

You can see the breakdown of the different bacterial infections found in VAP patients in table 2. Of the isolates tested, 35% were Klebsiella pneumoniae, 25% were Pseudomonas aeruginosa, and 20% were Acinetobacter baumannii. There has to be focused antibiotic treatment in intensive care units because Gram-negative bacteria are so common there.

Table 3: Antimicrobial Resistance Patterns of Key Bacterial Pathogens

Antibiotic	*Klebsiella pneumoniae* (n=21)	*Pseudomonas aeruginosa* (n=15)	*Acinetobacter baumannii* (n=12)
Carbapenems (Meropenem, Imipenem)	17 (81.0%)	10 (66.7%)	11 (91.7%)
Cephalosporins (Ceftriaxone, Ceftazidime)	19 (90.5%)	13 (86.7%)	12 (100%)
Aminoglycosides (Amikacin, Gentamicin)	15 (71.4%)	9 (60.0%)	10 (83.3%)
Fluoroquinolones (Ciprofloxacin, Levofloxacin)	16 (76.2%)	12 (80.0%)	11 (91.7%)
Colistin	3 (14.3%)	2 (13.3%)	2 (16.7%)
Tigecycline	4 (19.0%)	3 (20.0%)	2 (16.7%)

The patterns of antibiotic resistance among the most common bacterial isolates are shown in table 3. Aminoglycoside, carbapenem, and cephalosporin resistance rates were quite high; the rates were highest for Acinetobacter baumannii (91.7%) and Klebsiella pneumoniae (90.5%). To a lesser extent, most multidrug-resistant strains could still be effectively treated with colistin and tigecycline.

Table 4: Clinical Outcomes Based on Antimicrobial Resistance Status

Resistance Type	Number of Patients (n=60)	Mortality Rate (%)	ICU Stay (Mean ± SD days)
Non-MDR Infections	15	20.0	10.5 ± 3.2
MDR Infections	30	40.0	15.7 ± 4.1
XDR Infections	12	58.3	19.2 ± 5.3
PDR Infections	3	100.0	22.5 ± 6.7

The clinical outcomes of VAP patients, broken down by their antimicrobial resistance status, are shown in table 4. Patients with XDR infections had a substantially higher mortality rate of 58.3% and PDR infections of 100%. Antimicrobial resistance has a devastating effect on patient outcomes, as shown by the lengthy intensive care unit stays experienced by patients with MDR and XDR infections.

Discussion

Patients in critical care units (ICUs) continue to be at increased risk of ventilator-associated pneumonia (VAP), which can lead to serious complications and even death. This paper presents a cohort of sixty individuals with VAP and details their epidemiology, patterns of antibiotic resistance, and clinical outcomes. The results show that MDR bacteria are common, which is a factor in the bad health outcomes and extended hospital stays that patients experience [11, 12]. Acinetobacter baumannii (20%), Klebsiella pneumoniae (35%), and Pseudomonas aeruginosa (25%), were the most common bacterial infections found in patients with VAP in this research. This distribution is consistent with other research that found Gram-negative bacteria to be the most common cause of VAP. Because of their widespread antimicrobial resistance and well-documented involvement in nosocomial infections, Klebsiella pneumoniae and Acinetobacter baumannii's high prevalence is especially worrisome [12-14].

The results of antimicrobial susceptibility testing showed that the prevalence of resistance to widely used antibiotics is quite alarming. Acinetobacter baumannii (91.7%), Klebsiella pneumoniae (81.0%), and Pseudomonas aeruginosa (66.7%) were all found to be carbapenem resistant. The rising prevalence of carbapenem-resistant bacteria, such as carbapenem-resistant Enterobacteriaceae (CRE) and carbapenem-resistant Acinetobacter (CRA), is in line with this trend and presents serious obstacles to treatment. One of the most challenging bacteria to treat, Acinetobacter baumannii, had 100% resistance to cephalosporins, and this resistance was widespread [13-15].

Treatment strategies are further complicated by the fact that fluoroquinolones and aminoglycosides are not very effective against these multidrug-resistant infections. Even though resistance was still seen in some cases, the most effective agents were colistine and tigecycline. Since colistin is frequently seen as the antibiotic of choice for multidrug-resistant (MDR) and extensively drug-resistant (XDR) infections, the rise of isolates that are resistant to it is cause for grave concern [14-16].

Antimicrobial resistance and clinical outcomes are strongly correlated, according to the study's findings. Mortality rates were substantially higher for patients with multidrug-resistant (MDR) infections (40%), XDR infections (58.3%), and pan-drug-resistant (PDR) infections (100%) than for patients with any other type of infection. These findings

underscore the essential impact of antibiotic resistance on patient prognosis, as infections caused by MDR and XDR bacteria are often refractory to traditional therapies [15-17].

Multiple drug-resistant infections were linked to longer hospitalizations in the intensive care unit, which in turn increased death. Patients without multidrug-resistant infections spent an average of 10.5 days in the intensive care unit, but patients with MDR infections spent 15.7 days there. Longer hospital stays, higher healthcare expenditures, and an increased risk of secondary infections were all outcomes of patients infected with XDR and PDR strains. The prolonged use of mechanical ventilation in these patients further exacerbates the risk of developing recurrent infections, creating a vicious cycle of antibiotic use and resistance development [16-18].

The high prevalence of MDR, XDR, and PDR pathogens in VAP cases underscores the urgent need for robust antimicrobial stewardship programs. Empirical antibiotic therapy should be guided by local antibiograms and periodically updated resistance surveillance data to ensure appropriate medication selection. De-escalation strategies, in which broad-spectrum antibiotics are replaced with narrower-spectrum agents based on culture results, should be prioritized to minimize the emergence of further resistance [17-19].

In order to reduce the occurrence of ventilator-associated pneumonia (VAP), it is necessary to adhere to strict infection control measures such as thorough disinfection of ventilators, hand hygiene, and weaning techniques. The implementation of preventive strategies, such as selective digestive decontamination (SDD) and subglottic secretion drainage, may also help lower the burden of VAP in ICU settings [20].

Despite the valuable insights provided by this study, certain limitations must be acknowledged. The study was conducted in a single tertiary care hospital, which may limit the generalizability of the findings to other healthcare settings. Additionally, molecular characterization of resistance mechanisms was not performed, which could have provided a deeper understanding of the genetic basis of antimicrobial resistance in these pathogens. Future studies incorporating larger patient cohorts and advanced molecular techniques are warranted to further elucidate resistance trends and optimize treatment strategies [21-23].

Conclusion

The findings of this study emphasize the growing burden of antibiotic resistance in VAP cases, with significant frequencies of MDR and XDR infections leading to higher mortality and prolonged ICU stays. The preponderance of carbapenem-resistant Klebsiella pneumoniae and Acinetobacter baumannii offers a serious therapeutic issue, necessitating the cautious use of antibiotics and the deployment of strong infection control measures. To address the growing concern of resistant microorganisms in intensive care units, it is crucial to conduct continuous surveillance, adhere to antimicrobial stewardship practices, and create new treatment alternatives.

Conflict of Interest

None

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