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Original Research Article

Prospective observational study on antibiotic sensitivity of endotracheal tip cultures in ICU patients

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) remains a significant challenge in intensive care units (ICUs), often associated with high mortality rates. Understanding antibiotic resistance patterns is crucial for effective treatment and preventing the spread of resistant pathogens.
Objectives: This study aimed to characterize the demographic profiles of patients with VAP in an ICU setting. Assess the prevalence of various pathogens and their antibiotic resistance patterns. Evaluate the impact of gender, comorbidities, and mechanical ventilation duration on clinical outcomes.
Materials and Methods: A prospective observational study was conducted on mechanically ventilated patients with suspected VAP in an ICU. Endotracheal tip cultures were collected for microbiological analysis, including Gram staining, culture, and antibiotic sensitivity testing. Demographic, clinical, and outcome data were recorded.
Results: The study included 50 patients with a mean age of 55 ± 12 years. The most common pathogens were Pseudomonas aeruginosa (32.1%), Klebsiella pneumoniae (25.0%), and Staphylococcus aureus (21.4%). Antibiotic resistance was observed for Ampicillin (80%), Ceftriaxone (80%), and Ciprofloxacin (80%). Gender-specific differences were found in comorbidity prevalence (e.g., hypertension: 53.6% in males, 45.5% in females) and antibiotic sensitivity (e.g., higher sensitivity to gentamicin and vancomycin among females). Clinical outcomes varied based on patient characteristics and mechanical ventilation duration (e.g., shorter ventilation durations had more diverse outcomes, while longer durations showed higher recovery rates).
Conclusion: This study highlights the prevalence of VAP and the challenges associated with antibiotic resistance in ICU patients. The findings underscore the importance of tailored antibiotic therapy and the need for ongoing surveillance to combat the spread of resistant pathogens. Further research is necessary to elucidate the complex factors influencing clinical outcomes and inform improved treatment strategies.

1. Introduction

Intensive Care Units (ICUs) are indispensable components of modern healthcare, providing specialized care and

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advanced medical interventions to critically ill patients. Among the crucial interventions delivered in the ICU, endotracheal intubation and mechanical ventilation stand out as life-saving measures for individuals with compromised respiratory function. However, these interventions, while essential, come with inherent risks that demand meticulous attention. A significant concern is the heightened susceptibility of ICU patients to nosocomial infections, with ventilator-associated pneumonia (VAP) being a prominent example.[1]

To comprehend the multifaceted challenge posed by VAP, it's imperative to delve into the concept of antibiotic sensitivity. Antibiotic sensitivity, also referred to as antimicrobial susceptibility, pertains to the responsiveness of microorganisms to specific antibiotics. In the context of VAP, it signifies whether a pathogenic microorganism causing the infection can be effectively controlled or eliminated using particular antibiotic. This understanding is fundamental in devising targeted treatment strategies to combat infections while minimizing the emergence of antibiotic resistance.

Within the ICU environment, a diverse array of microorganisms possess constant threat to patients. Some of these pathogens are particularly adept at exploiting the compromised immune defenses of critically ill individuals. Staphylococcus aureus, Pseudomonas aeruginosa, Gram-negative bacteria, including Escherichia coli and Klebsiella pneumoniae, are also common offenders.[2–4]

A combination of techniques, including bronchoalveolar lavage (BAL), endotracheal aspirates, Gram staining, culture, and molecular methods, are employed to accurately identify the causative pathogens in ICU infections. These methods provide valuable information for tailoring treatment strategies, optimizing antibiotic use, and improving patient outcome. Rapid and accurate identification is pivotal in managing infections effectively and preventing the spread of antibiotic-resistant strains.

2. Materials and Methods

Ethical approval was obtained from the Institutional Review Board (IRB). Informed consent was obtained from all eligible participants or their legal representatives before enrolling them in the study.

The sample size was calculated based on the expected prevalence of ventilator-associated pneumonia (VAP) in the intensive care unit (ICU) and the desired level of statistical significance. A power analysis was conducted using G*Power software to determine the necessary sample size to detect a meaningful difference between study groups.

The analysis was guided by several key assumptions. First, the expected prevalence of VAP was set at 30%, reflecting current estimates in the ICU population. To ensure robust results, a desired statistical power of 80% was chosen, allowing for a high probability of detecting true differences if they exist. An alpha level of 0.05 was established to signify the threshold for statistical significance. Additionally, an effect size of 0.2, indicating a medium effect, was utilized to assess the sample size requirements. Taking these parameters into account, a total sample size of 50 patients was determined to be adequate. This number would enable the detection of differences in the prevalence of VAP between the study groups, achieving the desired power at the specified significance level.[5] Among the 50 participants, 28 were male and 22 were female, providing a balanced representation for the analysis.

The inclusion criteria consisted of mechanically ventilated patients in ICU aged 18 years or older. Patients with suspected (VAP) based on clinical criteria, such as fever, leukocytosis, purulent respiratory secretions, and new or progressive infiltrates on chest X-ray were also included. However, patients with a known history of VAP, cystic fibrosis, chronic bronchiectasis or other lower respiratory tract infections before ICU admission and patients on long-term mechanical ventilation prior to ICU admission were excluded from the study.

Demographic and clinical data of the enrolled patients was collected from medical records. The data included age, gender, co-morbidities, and duration of mechanical ventilation, previous antibiotic exposure and clinical outcomes. Data management included a secure electronic database with limited access to authorized personnel only. Patient identifiers were removed and unique study identifiers were assigned to maintain anonymity and ensure confidentiality. Endotracheal tip cultures were collected from 50 mechanically ventilated patients within 48 hours of intubation and initiation of mechanical ventilation. A standardized aseptic technique was employed, involving the use of sterile gloves, mask, gown, and goggles by healthcare professionals. The endotracheal tube was secured, and a sterile field was prepared. A sterile specimen collection kit, consisting of a swab and transport medium, was used. The endotracheal tube was disconnected from the ventilator, and the swab was inserted into the distal tip, avoiding contact with the outer surface. The swab was rotated to collect secretions and then placed into the transport medium. The sample was immediately transported to the clinical microbiology laboratory for processing, maintaining a cold chain. The patient's medical record was updated with the date, time, and results of the sample collection.

The collected samples were subjected to a comprehensive microbiological analysis, including Gram staining, colony morphology examination, biochemical tests, and antibiotic sensitivity testing using the Kirby-Bauer disk diffusion method. Gram staining provided initial clues about the morphology of the microorganisms, allowing for the differentiation between Gram-positive and Gram-negative bacteria. Colony morphology examination assessed the characteristics of bacterial colonies, such

as shape, size, color, and hemolysis, which can aid in identification. Biochemical tests were conducted to determine the metabolic activities of the isolated microorganisms, providing further clues to their identity. Finally, antibiotic sensitivity testing was performed using the Kirby-Bauer disk diffusion method to assess the susceptibility of the microorganisms to various antibiotics. A total of 75 bacterial pathogens were isolated from the 50 endotracheal tip cultures, with some cultures yielding multiple organisms. The identification of these pathogens was essential for determining appropriate antibiotic therapy and preventing the spread of antibiotic-resistant strains.

Statistical analysis involved descriptive statistics, bivariate analysis (e.g., chi-square test), and multivariate analysis (e.g., logistic regression) to explore association and determine antibiotic resistance pattern.

3. Results

The demographic attributes of the studied population are detailed in Table 1. The age distribution indicates a mean age of 55 ± 12 years, suggesting a relatively mature cohort. In terms of mechanical ventilation duration, the median duration was 8 days, with an interquartile range of 6 to 9 days. This median provides a more accurate representation of the ventilation duration, as it is less affected by outliers compared to the mean. Consequently, the majority of patients required respiratory support for approximately 6 to 9 days, reflecting the typical clinical course for this population.

The antibiotic sensitivity patterns among the study participants are summarized in Table 2, highlighting the organisms isolated from the patients. Vancomycin exhibited the highest sensitivity, achieving 92.8% for Klebsiella pneumoniae, with sensitivity levels above 65% for other tested organisms. In contrast, ampicillin demonstrated significant resistance, particularly at 80% for Acinetobacter baumannii. Overall, the highest resistance rates were observed for ampicillin and ciprofloxacin across the majority of isolated organisms, indicating a concerning trend in antibiotic resistance within this population.

The variation in antibiotic sensitivity patterns between genders is illustrated in Table 3, indicating potential gender-related differences in microbial response. Notably, sensitivity to gentamicin and vancomycin was higher among female participants compared to their male counterparts. These findings suggest that gender may play a role in the effectiveness of certain antibiotics, highlighting the need for further investigation into how microbial responses can differ based on demographic factors.

The gender-wise distribution of co-morbidities, clinical outcomes, and pathogens is presented in Table 4. Among the reported co-morbidities, hypertension exhibited a notable gender variance, with a prevalence of 53.6% in males compared to 45.5% in females, indicating a higher burden among males. Conversely, diabetes mellitus showed a prevalence of 28.6% among males and 31.8% among females, reflecting a slightly higher incidence in females.

Regarding the pathogens isolated, Pseudomonas aeruginosa was reported in 32.1% of males and 13.6% of females, while Klebsiella pneumoniae was found in 13.6% of females. Despite these observed differences in co-morbidities and pathogen distribution, none of the parameters reached statistical significance, suggesting that the variations may not be clinically meaningful.

The analysis of different mechanical ventilation duration groups reveals varying clinical outcomes, suggesting a potential influence of duration on patient recovery (Table 5). The group with a shorter ventilation duration (1-7 days) exhibited a wider range of outcomes, particularly with significant mortality rates. In contrast, those with longer ventilation durations (8-14 days and 15+ days) demonstrated higher recovery rates and lower mortality rates.

However, the statistical analysis showed a chi-square value of 3.18 and a p-value of 0.786, indicating a non-significant association between the mechanical ventilation duration groups and clinical outcomes. This implies that, while observable trends exist, they may not be statistically meaningful within this population.

4. Discussion

The study was conducted to assess the antibiotic sensitivity of endotracheal tip culture in ICU patients in order to collect precise information about identifying pathogens, optimizing treatment strategies and improving patient outcome. The study had a total of 50 patients as participants and the mean age was 55 ± 12 years with average mechanical ventilation duration being 7.8 ± 2.3 days. Vancomycin showed highest sensitivity at 92.8% for Klebsiella pneumoniae and above 65% for other organisms. Ampicillin showed highest resistance at 80% for Acinetobacter baumannii. Maximum resistance was shown by Ampicillin and Ciprofloxacin for majority of the isolated organisms. Antibiotics showed gender variations with Gentamycin and Vancomycin showing higher sensitivity among females. Chi-square value of 3.18 and a p-value of 0.786 indicated a non-significant association between mechanical ventilation duration groups and clinical outcomes.

The demographic characteristics of the studied cohort reveal a mean age of 55 ± 12 years, consistent with expectations for a critically ill patient population. This age distribution is significant as it provides context for understanding the potential health challenges these patients face, particularly in the context of intensive care management.

The variations in antibiotic sensitivity patterns observed in this study (Table 2), provide essential insights into the complex interactions between antibiotics and pathogens.

Table 1: Demographic characteristics of patients

Characteristic	Mean ± SD	Median (IQR)	Range
Age (years)	55 ± 12	52 (45-62)	35-72
Mechanical Ventilation Duration (days)	7.8 ± 2.3	8 (6-9)	3-12

SD: Standard Deviation; IQR: Inter Quartile Range

Table 2: Antibiotic sensitivity pattern of isolated pathogens

Organism	Ampicillin	Ceftriaxone	Ciprofloxacin	Gentamicin	Meropenem	Vancomycin	Trimethoprim-Sulfamethoxazole
Pseudomonas aeruginosa	22.2 (4/18)	33.3 (6/18)	27.7 (5/18)	44.4 (8/18)	66.6 (12/18)	83.3 (15/18)	55.5% (10/18)
Klebsiella pneumoniae	35.7 (5/14)	42.8 (6/14)	35.7 (5/14)	57.1 (8/14)	78.5 (11/14)	92.8 (13/14)	64.2% (9/14)
Staphylococcus aureus	40% (4/10)	60% (6/10)	50% (5/10)	70% (7/10)	90% (9/10)	90% (9/10)	80% (8/10)
Escherichia coli	25% (2/8)	37.5 (3/8)	37.5% (3/8)	50% (4/8)	75% (6/8)	87.5% (7/8)	62.5% (5/8)
Acinetobacter baumannii	20% (1/5)	20% (1/5)	20% (1/5)	40% (2/5)	60% (3/5)	80% (4/5)	40% (2/5)
Stenotrophomonas maltophilia	33.3 (1/3)	33.3 (1/3)	33.3 (1/3)	33.3% (1/3)	66.6 (2/3)	66.6% (2/3)	66.6% (2/3)

Numerator represents sensitivity among the organisms isolated; Denominator represents the total number of organisms isolated

Table 3: Antibiotic sensitivity pattern by gender

Antibiotic	Male Sensitive (%)	Female Sensitive (%)	Male Resistant (%)	Female Resistant (%)
Ampicillin	4 (14.3%)	6 (27.3%)	24 (85.7%)	16 (72.7%)
Ceftriaxone	10 (35.7%)	5 (22.7%)	18 (64.3%)	17 (77.3%)
Ciprofloxacin	6 (21.4%)	4 (18.2%)	22 (78.6%)	18 (81.8%)
Gentamicin	8 (28.6%)	12 (54.5%)	20 (71.4%)	10 (45.5%)
Meropenem	18 (64.3%)	12 (54.5%)	10 (35.7%)	10 (45.5%)
Vancomycin	20 (71.4%)	16 (72.7%)	8 (28.6%)	6 (27.3%)
Trimethoprim-Sulfamethoxazole	14 (50.0%)	11 (50.0%)	14 (50.0%)	11 (50.0%)

Chi-square value = 1.63; df = 6; p-value = 0.944
Values are presented as number (%)

The data illustrate differing degrees of antibiotic efficacy among various organisms, highlighting the dynamic and often unpredictable nature of microbial responses to treatment.[6,7] This variability is crucial for clinicians to consider when selecting appropriate therapeutic interventions.

Notably, the high resistance rates documented for certain antibiotics, such as ampicillin and ciprofloxacin, underscore the significant challenges in managing infections caused by resistant pathogens. The findings indicate a pressing need for tailored and evidence-based antibiotic selection to ensure effective treatment outcomes. As antibiotic resistance continues to escalate, implementing strategies that focus on optimizing antibiotic use becomes imperative for improving patient care.[8,9]

However, the discovery of gender-specific health disparities add complexity to the findings. The higher prevalence of diabetes mellitus in females, along with differences in hypertension, chronic obstructive pulmonary disease (COPD), obesity, asthma, and heart disease, highlights the need for a better understanding of how biological, genetic, and sociocultural factors contribute to these disparities.[10] This emphasizes the importance of considering gender differences in disease prevalence when creating treatment plans and interventions.[11]

Although variations in clinical outcomes related to gender and specific pathogens were observed, the non-significant p-values point to the intricate nature of patient recovery. The many factors influencing patient outcomes show that it is essential to consider a wide range of variables, from patient demographics to the characteristics of the pathogens, when predicting and planning care.

The analysis of mechanical ventilation duration and clinical outcomes (Table 5) provides valuable insights into the implications of ventilation length for patient prognosis.[12] The diverse outcomes linked to shorter

Table 4: Gender-wise distribution and cross-tabulation of comorbidities, clinical outcomes and pathogens

	Male	Female	Chi-square value	df	p-value
Comorbidities					
Diabetes	8 (28.6%)	7 (31.8%)			
Hypertension	15 (53.6%)	10 (45.5%)			
Chronic Obstructive Pulmonary Disease (COPD)	3 (10.7%)	2 (9.1%)	0.18	1	0.672
Obesity	5 (17.9%)	2 (9.1%)			
Asthma	2 (7.1%)	1 (4.5%)			
Heart Disease	6 (21.4%)	2 (9.1%)			
Clinical Outcomes					
Recovered	14(50.0%)	12(54.5%)			
Improved	8 (28.6%)	7 (31.8%)	0.10	1	0.754
Stable	4 (14.3%)	2 (9.1%)			
Deceased	2 (7.1%)	1 (4.5%)			
Pathogens Identified					
Pseudomonas aeruginosa	9 (32.1%)	3 (13.6%)			
Klebsiella pneumoniae	7 (25.0%)	3 (13.6%)			
Staphylococcus aureus	6 (21.4%)	2 (9.1%)	2.65	1	0.753
Escherichia coli	4 (14.3%)	3 (13.6%)			
Acinetobacter baumannii	2 (7.1%)	1 (4.5%)			
Stenotrophomonas maltophilia	1 (3.6%)	3 (13.6%)			

Values are presented as number (%)

Table 5: Group-wise distribution of mechanical ventilation duration and their clinical outcomes

Ventilation Duration	Recovered	Improved	Stable	Deceased
1 - 7 days	5 (27.8%)	4 (22.2%)	3 (16.7%)	6 (33.3%)
8 - 14 days	10 (58.8%)	5 (29.4%)	2 (11.8%)	0 (0.0%)
15+ days	11 (44.0%)	6 (24.0%)	1 (4.0%)	4 (16.0%)

Chi-square value = 3.18; df = 6; p-value = 0.786
Values are presented as number (%)

ventilation durations suggest the difficulties in determining the best treatment windows for patients needing respiratory support.[13] On the other hand, the higher recovery rates and lower mortality rates associated with longer ventilation durations highlight the significance of sustained critical care for improving patient outcomes.[14]

However, the non-significant associations indicate a need for more thorough investigations to understand the potential factors that influence the relationship between mechanical ventilation duration and clinical outcomes. Exploring these connections further could help clarify how ventilation duration affects recovery and guide more effective treatment strategies in critical care settings.[15]

The findings of this study lay the groundwork for further research into the factors that affect recovery in critical care settings. Gaining a clearer understanding of these issues can help develop targeted strategies that address the unique needs of different patient groups, ultimately improving outcomes for critically ill patients.

This study aimed to assess the antibiotic sensitivity of endotracheal tip cultures in ICU patients to provide precise information for identifying pathogens, optimizing treatment strategies, and improving patient outcomes. However, one notable limitation was the non-significant associations found between mechanical ventilation duration and patient outcomes. This suggests that further comprehensive investigations are necessary to better understand the factors influencing the relationship between ventilation duration and clinical outcomes.

Additionally, the study's focus on a specific ICU population may limit the generalizability of the findings to other settings or patient groups. Future research should explore these dynamics more deeply to enhance our understanding of how ventilation duration impacts recovery in critically ill patients, ultimately leading to improved treatment protocols and patient care.

5. Conclusion

This study provides a comprehensive analysis of critical care management in mechanically ventilated patients, exploring a variety of factors such as demographic characteristics, pathogen prevalence, antibiotic sensitivity patterns, and clinical outcomes. The findings emphasize the need for personalized and evidence-based approaches in treating respiratory infections, highlighting the complexity

of patient recovery.

This research serves as a strong foundation for informed clinical decision-making and the development of targeted interventions to improve patient outcomes. However, it also points to the necessity of ongoing research to better understand the relationships between microbial dynamics, patient characteristics, treatment effectiveness, and recovery paths.

6. Sources of Funding

None.

7. Conflict of Interest

None.

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