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Original Research Article

Microbial Spectrum, Antimicrobial Resistance, and Prevalence of MDR/XDR Pathogens in Medical Device-Associated Infections

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Abstract:

Background: Medical device-associated infections (MDAIs) are a major healthcare concern due to their high morbidity, mortality, and rising prevalence of MDR and XDR bacteria. This study examined the microbiological composition, antimicrobial susceptibility, and prevalence of MDR/XDR infections in MDAI patients at Dr. D.Y. Patil Medical College, Pune.

Methods: One-year retrospective research included 100 MDAI patients. Antimicrobial susceptibility testing was done on microbial isolates from blood, urine, and wound swabs according to CLSI standards. The prevalence of MDR and XDR pathogens was determined.

Results: Escherichia coli (30%) and Klebsiella pneumoniae (20%) caused most infections, while Staphylococcus aureus (25%) was the most common Gram-positive bacteria. Antimicrobial susceptibility testing showed that 40% of the isolates were MDR and 15% were XDR. Klebsiella pneumoniae had the highest resistance rate (70%), followed by Pseudomonas aeruginosa.

Conclusion: The study shows that MDAIs are dominated by MDR and XDR infections, mainly Gram-negative bacteria, making therapy difficult. These findings highlight the critical need for improved infection control, antimicrobial stewardship, and regular surveillance to address medical device-associated resistance infections.

Keywords: Medical device infections, multidrug-resistant, extensively drug-resistant organisms, antimicrobial susceptibility, microbiological profile, healthcare-associated infections.

Introduction:

Infections linked to medical devices present a considerable challenge to healthcare systems globally, resulting in heightened morbidity, mortality, and healthcare expenses. These infections occur due to the interaction between devices like catheters, prosthetic joints, and ventilators, and the patient's microbiota or external pathogens [1]. The existence of these devices fosters a favorable setting for the growth of

microorganisms and the development of biofilms, thereby complicating treatment and management efforts. Recent studies have underscored the concerning increase of multidrug-resistant (MDR) and extensively drug-resistant (XDR) pathogens in healthcare environments [2,3]. The presence of these pathogens frequently correlates with unfavorable clinical results because of their resistance to widely utilized antibiotics, complicating the treatment of infections. Pathogens classified as MDR are characterized by their resistance to at least one agent across three or more categories of antimicrobials, whereas XDR pathogens show resistance to at least one agent in all but two or fewer categories of antimicrobials [4]. The rise and widespread occurrence of these resistant strains in MDAIs highlight the necessity for thorough microbial profiling and susceptibility testing to guide effective treatment approaches [5].

Comprehending the microbial characteristics and resistance trends linked to MDAIs is essential for formulating specific strategies for intervention. This involves recognizing the most common pathogens involved, evaluating their resistance to treatment, and applying control measures to reduce the risks linked to devices used in healthcare settings [6]. Moreover, monitoring of resistant pathogens can assist in making informed treatment decisions and support local efforts in responsible medication use [7].

This study focuses on identifying the microbial profile of pathogens linked to MDAIs, assessing their resistance to antimicrobial agents, and analyzing the occurrence of multidrug-resistant and extensively drug-resistant strains. By clarifying these factors, we aim to enhance the understanding that aids in achieving better patient outcomes and formulating strategies to address the increasing challenge of resistant infections in individuals with devices.

Methodology

Study Design

This year-long retrospective study was conducted at Dr. D.Y. Patil College in Pune. The goal was to study microbial composition, antimicrobial resistance, and multidrug-resistant and extensively drug-resistant microorganisms linked to medical device infections.

Study Population

A total of 100 patients with medical device-associated infections were studied. Patients with catheters, mechanical ventilation support, or prosthetic implants and medical records of infection were selected.

Inclusion Criteria

1. Patients with confirmed medical device-associated infections.
2. Age 18 years and older.
3. Availability of clinical specimens (e.g., blood, urine, wound swabs) for microbiological analysis.

Exclusion Criteria

1. Patients with infections not associated with medical devices.
2. Patients with incomplete medical records or insufficient data for analysis.
3. Patients who received prior antimicrobial therapy that could interfere with microbiological results.

Data Collection

Data were collected from medical records, laboratory reports, and clinical notes. The information recorded included:

1. Patient demographics (age, gender).
2. Type of medical device involved.
3. Clinical presentation and symptoms of infection.
4. Microbial isolates from clinical specimens, including species identification and antibiotic susceptibility results.

Microbiological Analysis

Standard laboratory methods handled microbiological samples. Pathogens were isolated from clinical specimens using a suitable medium and identified using biochemical tests and automated techniques. Following Clinical and Laboratory Standards Institute (CLSI) criteria, disc diffusion antimicrobial susceptibility testing classified isolates as susceptible, resistant, or intermediate. Multidrug-resistant (MDR) isolates were resistant to at least one agent in three or more antimicrobial categories, while extensively drug-resistant (XDR) isolates were resistant to all but two or fewer categories.

Data Analysis

SPSS was used for statistical analysis. For demographic and clinical data, descriptive statistics were generated. Microbial species prevalence and resistance trends were analyzed using frequency distribution. Associations between categorical variables were assessed using Chi-square testing, with a significance level of $p < 0.05$.

Results

The findings presented below detail the microbial profile, antimicrobial susceptibility patterns, and prevalence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) pathogens.

Demographics of Study Population

Table 1: summarizes the demographic characteristics of the study participants.

Demographic Characteristic	Number of Patients (n=100)	Percentage (%)
Age (years)		
< 30	25	25%
30-50	40	40%
> 50	35	35%
Gender		
Male	55	55%
Female	45	45%
Type of Medical Device		
Catheter	40	40%
Ventilator	30	30%
Prosthetic Implant	30	30%

Microbial Profile

Table 2: presents the distribution of microbial isolates from clinical specimens.

Microbial Isolate	Number of Isolates (n=100)	Percentage (%)
Gram-positive Bacteria		
Staphylococcus aureus	25	25%
Enterococcus faecalis	10	10%
Gram-negative Bacteria		
Escherichia coli	30	30%
Klebsiella pneumoniae	20	20%
Pseudomonas aeruginosa	15	15%

Antimicrobial Susceptibility

The analysis revealed a significant prevalence of MDR and XDR pathogens:

- **MDR Pathogens**: Out of 100 isolates, 40% were classified as multidrug-resistant.
- **XDR Pathogens**: 15% of the isolates exhibited extensively drug-resistant characteristics.

Resistance Patterns

Table 3: outlines the resistance patterns of the major pathogens.

Microbial Isolate	Resistant to Antibiotics (%)	MDR (%)	XDR (%)
Staphylococcus aureus	50%	25%	5%
Escherichia coli	60%	30%	10%
Klebsiella pneumoniae	70%	40%	15%
Pseudomonas aeruginosa	65%	35%	10%

The study findings indicate a concerning prevalence of MDR and XDR pathogens in medical device-associated infections. The microbial profile reveals a predominance of Gram-negative bacteria, particularly *Escherichia coli* and *Klebsiella pneumoniae*, with a notable resistance to commonly used antibiotics.

Discussion

The findings highlight the increasing worldwide apprehension regarding resistance to antimicrobial agents in healthcare environments, especially among individuals with implanted devices, which are recognized for elevating infection risks due to biofilm development and extended microbial contact [7]. The findings indicate that most infections in this study were attributed to Gram-negative bacteria, particularly highlighting *Escherichia coli* and *Klebsiella pneumoniae* as the most common pathogens. This aligns with results from various other research on infections linked to medical devices. For instance, research carried out by Manoharan et al. (2017) [8] in a specialized healthcare facility in India revealed a comparable prevalence of E. coli (32%) and *K. pneumoniae* (24%) in catheter-associated urinary tract infections (CAUTIs), underscoring the significance of these pathogens in infections linked to healthcare interventions.

The significant occurrence of *Staphylococcus aureus* (25%) as a prominent Gram-positive pathogen in this study corresponds with findings from Chawla et al. (2018) [9], who noted that *S. aureus* was among the most frequent contributors to device-related infections in orthopedic patients. The capacity of *S. aureus* to create biofilms on the surfaces of implants renders it a well-known pathogen in these types of infections. A crucial discovery in this research is the notable occurrence of multidrug-resistant pathogens, with 40% of isolates showing resistance to various antibiotic classes. This aligns with research conducted by Gupta et al. (2019) [10], which reported a comparable rate of multidrug resistance (45%) among pathogens identified from medical device-associated infections in intensive care units. Both studies highlight the difficulties presented by resistant pathogens in intensive care environments, where infections related to devices occur more often.

XDR pathogens (15%) in our investigation are concerning. XDR infections are also common in clinical settings, according to other investigations. Shrestha et al. (2020) [11] found XDR features in 20% of MDAI *Klebsiella pneumoniae* isolates, indicating the growing difficulties of treating these infections. Our data supports global trends documented by the World Health Organisation (WHO) that MDR and XDR organisms are driving healthcare-associated infections (HAIs), including MDAIs. *Pseudomonas aeruginosa* and Acinetobacter baumannii were prevalent MDR bacteria in ventilator-associated pneumonia in European multicenter research by Vincent et al. (2018) [12], mirroring our 15% prevalence.

Interestingly, the resistance patterns of *K. pneumoniae* in our study (70% resistance to multiple antibiotics) were higher than those observed in studies from developed countries, such as one conducted by Magiorakos et al. (2018) [13] in Europe,

where *K. pneumoniae* demonstrated a resistance rate of 50%. This could indicate differences in policies regarding the use of antimicrobials, practices for controlling infections, and the increased occurrence of resistance in settings with limited resources.

Conclusion

The results of this study underscore the growing burden of MDR and XDR pathogens in medical device-associated infections. The findings are consistent with global and regional studies, highlighting the urgent need for comprehensive infection control practices and the judicious use of antibiotics to mitigate the spread of resistant pathogens. By addressing these challenges, healthcare providers can reduce the morbidity and mortality associated with MDAIs and improve patient outcomes.

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