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Original Research Article

Microbial Characteristics, Antimicrobial Resistance, and Prevalence of Multidrug-Resistant and Extensively Drug-Resistant Organisms in Device-Associated Infections: A Study at a Single Healthcare Center

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Abstract:
This 12-month retrospective cohort study at a single tertiary healthcare center examined the microbial profile, antimicrobial susceptibility, and prevalence of MDR and XDR pathogens in medical device-associated infections. Urinary catheters, central venous catheters, mechanical ventilators, and orthopedic prostheses were evaluated in 250 patients. The study found Staphylococcus aureus, E. coli, Pseudomonas aeruginosa, and Enterococcus spp. as the most common pathogens, along with Candida spp. MDR pathogens were 45% prevalent and XDR pathogens were 15% commonplace in antimicrobial susceptibility testing. Device type and pathogen type were strongly connected, and MDR pathogens were strongly associated with unfavorable clinical outcomes such as prolonged hospital admissions and increased death. The findings emphasize the necessity for strict infection control and judicious antibiotic use to tackle MDAIs' high MDR and XDR pathogen burden.

Keywords: Medical Device-Associated Infections, Multidrug-Resistant Pathogens, Antimicrobial Susceptibility, Infection Control Strategies.

Introduction

In healthcare settings worldwide, dealing with medical device-associated infections (MDAIs) is becoming increasingly challenging. These infections are linked to higher morbidity rates, longer hospital stays, and increased healthcare expenses [1]. Infections can occur due to different medical devices such as catheters, prosthetics, and ventilators. They are primarily caused by the presence of harmful microorganisms on these devices [2]. Recognizing the microbial profile and antimicrobial susceptibility of the pathogens involved is crucial in effectively managing these infections. It is important to note that these pathogens are becoming more characterized by multidrug-resistant (MDR) and extensively drug-resistant (XDR) profiles [3,4].

The cause of MDAIs is multifaceted, encompassing the patient's natural bacteria and the microorganisms present in the hospital surroundings. There are several types of bacteria, including Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, and various species of Enterococci. Fungi and viruses can also have an impact in specific situations. The emergence of MDR and XDR strains among these pathogens is a cause for significant concern, as it severely restricts the available treatment options and adds complexity to infection control efforts [5,6].

Accurate assessment of antimicrobial susceptibility is crucial for guiding treatment plans and keeping track of resistance trends. Nevertheless, the increase in antimicrobial resistance (AMR) has created an urgent demand for innovative treatment methods and stricter infection control protocols [7]. This study conducted at a single center focuses on analyzing the microbial profile, evaluating the susceptibility of antimicrobials, and determining the prevalence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) pathogens in infections associated with medical devices. This research aims to provide valuable insights into the dynamics of MDAIs, which can help improve clinical management and guide targeted interventions in healthcare [8,9].

Additionally, this study highlights the importance of following strict sterilization protocols, using antimicrobials responsibly, and incorporating innovative technologies and materials to prevent the buildup of biofilms and the growth of microorganisms on medical devices. Healthcare facilities can gain a greater awareness of the

microbial landscape and resistance mechanisms to effectively anticipate and address the challenges posed by these formidable infections.

Methodology

Study Design and Setting: This 12-month retrospective cohort research was undertaken at a single tertiary healthcare centre. This study examines hospitalized patients with medical device-associated infections (MDAIs).

Participant Selection: Patients of any age who developed catheter, ventilator, or prosthesis infection throughout the study period are eligible. Patients with community-acquired infections or device-related infections from devices implanted elsewhere are excluded.

Sample Size: The study comprised 250 patients based on inclusion and exclusion criteria. This sample size had the power to identify significant variations in MDR and XDR pathogen prevalence among patients.

Data Collection: Systematic data was collected from hospital EHRs and infection control monitoring systems. Patient demographics, medical device type, period of use, infection site, presenting symptoms, and clinical outcomes were collected. The laboratory information management system also provided pathogen identification and antibiotic susceptibility data.

Microbiological Analysis: Standard culture and biochemical testing identified pathogens. According to CLSI recommendations, Kirby-Bauer disc diffusion was used to test antimicrobial susceptibility. CDC criteria classified microorganisms as MDR or XDR.

Statistical Analysis: Patient demographics, infectious features, and microbiological data were described using descriptive statistics. MDR and XDR prevalence rates were determined as a percentage of pathogen isolates. Continuous variables were analyzed using Student's t-test, while categorical variables were compared using Chi-square and Fisher's exact tests. The significance level was set at $p<0.05$.

Results

The study involved 250 patients who had infections related to medical devices. The participants' ages ranged from 20 to 85 years, with an almost equal distribution between males and females. Urinary catheters were found to be the most common devices linked to infections, accounting for 40% of cases. Central venous catheters followed closely behind at 25%, while mechanical ventilators and orthopedic prosthetics accounted for 20% and 15% respectively.

A wide range of pathogens was found in the infected areas. The most commonly found organisms were Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Enterococcus spp. Approximately 10% of the infections were caused by fungal pathogens, specifically Candida spp.

There were different resistance patterns observed among the isolated pathogens during the antimicrobial susceptibility testing. It was discovered that 45% of the pathogens were MDR, with XDR pathogens being less prevalent at approximately 15% of the isolates. Here is a summary of the resistance patterns to commonly used antimicrobials:

Pathogen	Resistance to Ciprofloxacin (%)	Resistance to Vancomycin (%)	Resistance to Meropenem (%)	MDR (%)	XDR (%)
S. aureus	35	5	N/A	40	10
E. coli	50	N/A	40	55	15
P. aeruginosa	60	N/A	50	65	20
Enterococcus spp.	20	30	N/A	25	5
Candida spp.	N/A	N/A	N/A	10	0

Through statistical analysis, it was found that there were significant connections between different types of devices and the pathogens they were associated with ($p<0.05$). It was observed that urinary catheters were most commonly linked to *E. coli* infections, while mechanical ventilators were frequently associated with *P. aeruginosa*.

There was a strong correlation between the presence of MDR pathogens and longer hospital stays ($p<0.01$), as well as higher mortality rates ($p<0.05$).

Discussion

The study reveals a significant occurrence of drug-resistant pathogens in infections associated with medical devices at a specialized healthcare facility. The prevalence of MDR pathogens, specifically in Pseudomonas aeruginosa and Escherichia coli, aligns with worldwide patterns, highlighting the urgent requirement for improved antimicrobial stewardship and infection control protocols [10]. There is a clear link between certain devices and the presence of pathogens. For example, urinary catheters are often associated with E. coli infections, while mechanical ventilators are linked to P. aeruginosa infections [11]. This suggests that protocols tailored to each device could be improved to lower the risk of infections. In addition, the strong link between the existence of MDR pathogens and negative consequences such as longer hospital stays and higher mortality rates highlights the serious consequences of antimicrobial resistance on patient outcomes [12].

The results of our study align with the research conducted by Smith et al. (2021) [16]. They discovered a high prevalence of multidrug-resistant pathogens in medical devices associated with multiple healthcare facilities in North America. In a recent European study conducted by Lopez et al. (2020) [17], it was discovered that device-associated infections were primarily attributed to certain bacteria, including Staphylococcus aureus and Pseudomonas aeruginosa. Alarmingly, the study revealed that resistance levels against Pseudomonas aeruginosa reached as high as 50%, particularly against fluoroquinolones and carbapenems.

On the other hand, a study conducted in Asia by Chang and Lee (2019) [18] emphasized a decreased occurrence of XDR pathogens. They attributed this to the implementation of strict infection control measures and proactive antimicrobial stewardship programs. Variations in healthcare practices across different regions can have a profound impact on the microbial environment and patterns of resistance in MDAIs.

This study has some limitations due to its retrospective design and single-center setting. It may not provide a complete representation of the broader demographic and microbial diversity observed in other regions or healthcare systems. In addition, the use of electronic health records and laboratory reports may have led to biases in the selection process or errors in data entry [13]. Additional research should prioritize longitudinal and multicentric studies to gain a deeper understanding of the dynamics of MDR and XDR pathogens in MDAIs. It would be beneficial to conduct prospective studies to investigate how certain antimicrobial stewardship programs and infection control protocols affect the frequency and severity of these infections [14,15].

Conclusion

This study shows that MDR and XDR bacteria are common in medical device-associated infections (MDAIs) at a tertiary healthcare center. The correlation between specific devices and pathogen types and the strong association between MDR pathogens and adverse clinical outcomes like prolonged hospital stays and increased mortality emphasize the need for better infection control and antimicrobial use. The findings suggest targeted antibiotic stewardship and improved preventative strategies to manage and minimize MDAIs, improving patient outcomes and lowering healthcare expenditures. This work could inform healthcare policy and procedures to address MDR and XDR infections.

References

1. Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. Infect Control Hosp Epidemiol. 2013 Nov;34(1):1-14.
2. Hidron AI, Edwards JR, Patel J, Horan TC, Sievert DM, Pollock DA, et al. NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006-2007. Infect Control Hosp Epidemiol. 2008 Dec;29(11):996-1011.
3. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis. 2009 Jul 1;49 (1):1-45.
4. Weinstein RA, Darouiche RO. Device-associated infections: a macroproblem that starts with microadherence. Clin Infect Dis. 2001 Nov 15;33(10):1567-72.
5. Chopra V, Anand S, Hickner A, Buist M, Rogers MA, Saint S, et al. Risk of venous thromboembolism associated with peripherally inserted central catheters: a systematic review and meta-analysis. Lancet. 2013 Jul 13;382 (98 89):311-25.
6. Raad I, Darouiche R, Dupuis J, Abi-Said D, Gabrielli A, Hachem R, et al. Central venous catheter coated with minocycline and rifampin for the prevention of catheter-related colonization and bloodstream infections. A random-

ized, double-blind trial. Ann Intern Med. 1997 Aug 15;127(4):267-74.
7. Gaynes R, Edwards JR. Overview of nosocomial infections caused by gram-negative bacilli. Clin Infect Dis. 2005 Sep 15;41(6):848-54.
8. Vincent JL, Rello J, Marshall J, Silva E, Anzueto A, Martin CD, et al. International study of the prevalence and outcomes of infection in intensive care units. JAMA. 2009 Dec 2;302 (21):2323-9.
9. Safdar N, Maki DG. The pathogenesis of catheter-related bloodstream infection with non-cuffed short-term central venous catheters. Intensive Care Med. 2004 Jan;30(1):62-7.
10. Timsit JF, Schwebel C, Bouadma L, Geffroy A, Garrouste-Orgeas M, Pease S, et al. Chlorhexidine-impregnated sponges and less frequent dressing changes for prevention of catheter-related infections in critically ill adults: a randomized controlled trial. JAMA. 2009 Mar 25;301(12):1231-41.
11. Eggimann P, Harbarth S, Constantin MN, Touveneau S, Chevrolet JC, Pittet D. Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care. Lancet. 2000 May 27;355(9218):1864-8.
12. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis. 2011 May;52(9):e162-93.
13. Bouza E, Burillo A, Munoz P. Catheter-related infections: diagnosis and intravascular treatment. Clin Microbiol Infect. 2002 Apr;8(4):265-74.
14. Marschall J, Mermel LA, Fakih M, Hadaway L, Kallen A, O'Grady NP, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014 Jul;35(7):753-71.
15. Blot SI, Depuydt P, Annemans L, Benoit D, Hoste E, De Waele JJ, et al. Clinical and economic outcomes in critically ill patients with nosocom
16. Smith, J. D., et al. "Multidrug-resistant organisms in hospital-acquired infections: A 12-month study." Journal of Infection Prevention, 2021;22(2): 74-80.
17. Lopez, R., et al. "Antimicrobial resistance patterns in ventilator-associated pneumonia: a European multicenter cohort study. Infection Control & Hospital Epidemiology, 2020;41(7): 674-680.
18. Chang, Y., Lee, C. "Effectiveness of infection control programs against device-associated infections in Asian countries: A systematic review." Journal of Hospital Infection, 2019; 102(4): 414-423.