

ANTIMICROBIAL SUSCEPTIBILITY, MICROBIAL PROFILE AND PREVALENCE OF MDR/XDR PATHOGENS CAUSING MEDICAL DEVICE-ASSOCIATED INFECTIONS: A SINGLE CENTRE STUDY.

Kunal Raj¹, Jag Mohan Kumar¹, Lalchand Tudu², Pradip Kumar Bhattacharya³, Amit Kumar^{1}*
Senior Resident, Department of Critical Care Medicine, RIMS, Ranchi, Jharkhand, India¹
Assistant Professor, Department of Critical Care Medicine, RIMS, Ranchi, Jharkhand, India²
HOD, Department of Critical Care Medicine, RIMS, Ranchi, Jharkhand, India³

ABSTRACT

Background

The development of nosocomial infection associated with pathogens that are multi-drug resistant and extensively drug-resistant leads to serious complications in hospitalized patients. Since this type of infection has limited treatment options it is necessary to identify and determine their prevalence. This study is conducted to determine the Microbial Profile, Antimicrobial Susceptibility, and Prevalence of MDR/XDR Pathogens Causing Medical Device Associated Infections at our institute.

Materials and Methods

The patients admitted at the RIMS Ranchi were included in the study. The demography and other clinical characteristics of the patients were recorded. The CLABSI, CAUTI, and VAP were confirmed in the patients. The causative pathogen was isolated. The microbiology profile, resistance, and susceptibility pattern of these organisms were studied.

Results

Among the 110 patients, 65 were confirmed to have MDAs based on positive culture results. The average age of the patients was 43.5 ± 5 years, with a majority being male. Comorbidities included liver disorders (30.7%), cardiovascular disorders (29.2%), and renal disorders (21.3%). Immunosuppression was seen in 80% of patients. The infections identified were central line-associated bloodstream infections (53.8%), catheter-associated urinary tract infections (23.07%), and ventilator-associated pneumonia (23.07%). Of the 80 pathogens isolated, 54 were MDR, and 20 were XDR. Carbapenem resistance was noted in 35% of the isolates. Fungal resistance to amphotericin B and fluconazole was observed in 8.75% of cases. Two patients with ventilator-associated pneumonia did not survive.

Conclusion

MDAs are inevitable, among them central-line bloodstream infection is found in most patients. The occurrence of resistance among the patients severely reduces the treatment options available and increases the complexities of the treatment.

Recommendation

Preventative measures and analysis of microbiology profiles are necessary to reduce the occurrence of infection associated with medical devices.

Keywords: Nosocomial infection, Medical devices, Catheter, Pathogens

Submitted: 2024-09-06 Accepted: 2024-09-07

Corresponding author: Amit Kumar

Email: dramitkumar73@gmail.com

Senior Resident, Department of Critical Care Medicine, RIMS, Ranchi, Jharkhand, India

INTRODUCTION

The nosocomial infections associated with medical devices can add to the complexities related to the treatment of hospitalized patients. Life-saving devices such as ventilators can prove to be fatal if biofilms of pathogens are formed on them. The other devices that most common sources of

nosocomial infection are the central line catheter which is introduced in the bloodstream and the catheter which is introduced in the urinary tract [1]. The catheter introduced in the bloodstream can cause systemic infection, the catheter introduced in the urinary tract can cause urinary tract infection, and the ventilator can lead to pneumonia. Apart from that surgical site infection and another type of infection

developed in the patient during the hospital stay cause major complications.

Medical device-associated infections can vary from one institute to the other, while considering developed countries such kinds of infection are constant on average in each institute [2]. However, the pattern of occurrence of such infection is varying considering the developing countries. This can be attributed to the sterilization protocols, population, microorganism naturally occurring in patients, treatment given, and development of resistance in the microorganism. The development of resistance in the microorganisms can increase the pathogenicity of the microorganisms, which further decreases their susceptibility towards antimicrobials. The resistance of the microorganisms can severely limit the treatment options available to healthcare professionals [3,4].

The multi-drug resistant microorganisms are those which are resistant to more than 3 classes of antimicrobials. Extensively drug-resistant microorganisms are those that are resistant to at least one agent in all but two or fewer antimicrobial categories (i.e., bacterial isolates remain susceptible to only one or two antimicrobial categories). The development of resistance causes increased virulence of the microorganism which decreases their susceptibility towards antimicrobials. The resistant organism can be *Staphylococcus aureus*, *Candida albicans*, *Enterobacteriaceae*, etc. The resistant pathogens are difficult to be handled by the body's natural immune system which might lead to sepsis [5,6]. Sepsis can affect different body parts including the cardiovascular system and nervous system. It can lead to multiple organ failure, thus infection due to resistant pathogens can prove to be fatal for patients suffering from nosocomial infection. Extensively resistant pathogens and multidrug-resistant pathogens can affect community health, and it also requires the development of newer antimicrobials [7].

Studying the pattern of the microorganism that gets deposited as a biofilm on medical devices can help develop preventive measures. Such studies can also aid in understanding the development of resistance and the susceptibility of the microorganism which can hasten the process of development of newer antimicrobials. Since developing countries like India have myriads of differences in the microbiology profile of the biofilms on medical devices, it is necessary to evaluate the microbiology profile at the institute level. This study is conducted to determine the Microbial Profile, Antimicrobial Susceptibility, and Prevalence of MDR/XDR Pathogens Causing Medical Device Associated Infections at our institute.

METHODS

Study design

The study was conducted ambispective cohort design, that is the data was collected retrospectively from the medical records of the patients who were discharged and those who were hospitalized they were monitored prospectively.

Study setting

This study was conducted from March 2022 to September 2024 and the data of the patients was collected during this period at RIMS, Ranchi.

Participants

The participants included 110 patients admitted to RIMS Ranchi with suspected medical device-associated infections.

Bias

Potential bias in the study could stem from the exclusion of patients who were not recommended for catheter removal by physicians, as well as limitations in laboratory capabilities that may have prevented the isolation of certain pathogens.

Variables: The variables in this study include age, gender, comorbidities (renal, cardiovascular, liver, respiratory disorders), immune status (compromised/competent), type of infection (central line-associated bloodstream infection, catheter-associated urinary tract infection, ventilator-associated pneumonia), site of cannulation (femoral vein, basilic vein, jugular vein), duration of medical device use (>12 days, <12 days), duration of hospital stay (>7 days, <7 days), and survival rate.

Data sources/measurements

The patients who had hospital stays equal to or more than 48 hours were taken into consideration. The patients who had catheterization in the central line, in the urinary tract either suprapubic or indwelling, and the patients who had intratracheal tubes for respiratory support were included in the study. Three typical infections were identified in this study, central line-associated blood infection, urinary tract infection, and ventilator-associated pneumonia. The patients who had undergone Hickmann's catheterization, pregnant women, undergoing chemotherapy, had chronic disease, and pediatric patients were not included in the study.

The patients who showed symptoms of infections such as fever were considered further in the study. The data of such patients which included, the presence of comorbidity, immune health status, no. of catheter, site of cannulation, duration of catheterization, hospital stay, culture of bacteria

isolated, microbiology profile, its susceptibility, its resistance towards antimicrobials, the antimicrobial prescribed for treatment of infection, history of the patients, and cause of hospitalization were recorded.

From the patients showing the presence of symptoms of blood infection two blood samples were collected aseptically, one from the arm with a catheter and the second one from the other arm. The samples were handled as per the standard microbiology protocols. The colony-forming units of more than 15 in these samples were considered to have significant infection. The urine sample was collected from the patients who had urinary catheters using an aseptic technique. The samples were culture tested and the colony-forming units of more than 10⁵ were considered to have significant infection. The bronchoalveolar lavage was collected from the patients who had intratracheal tubes and showed the symptoms of pneumonia. The sample was culture tested the colony-forming units of more than 10⁵ were considered to have significant infection. The

microbiological profile of the isolated organism, the resistance towards carbapenems, and the susceptibility of the antimicrobials were tested from each sample collected.

Statistical analysis

The data obtained was arranged on an Excel sheet in a tabulated manner and the data was analyzed thoroughly for the significance of the infections that were associated with medical devices.

Ethical consideration

The approval for the conduction of the study was obtained from the institutional ethics committee and informed consent was obtained from these patients.

RESULTS

Table no.1: Medical device-associated infection identified

Medical device used	Bacterial species isolated	Fungal species isolated
Central line venous catheter	25	20
Catheter in the urinary tract	15	5
Ventilator	15	-

There were a total of 110 suspected to have medical device-associated infection out of which 33 patients were on urinary catheters, 56 were using central venous catheters, and 21 had central catheter inserted peripherally. Out of 110 patients, 50 showed positive culture test and the medical device-associated infection was confirmed in these patients. In this study, 50 patients required mechanical ventilation, and ventilator-associated pneumonia was found to be positive in 15 patients. Overall, 65 patients had positive culture tests and had infections related to medical devices. From 65

patients there were 80 pathogens isolated. 55 of the 80 pathogens were bacterial isolates and 25 were fungal isolates. 25 were central line-associated bloodstream bacterial infections, 20 were central line-associated bloodstream bacterial infections, 15 had catheter-associated urinary tract bacterial infections, 5 were catheter-associated urinary tract fungal infections, and 15 patients had bacterial ventilator-associated pneumonia. Table no.1 gives details of the medical device used and the species isolated.

Table no.2: Characteristics of the patient

Sr no.	Characteristics	Frequency (%)
1	Associated comorbidities	
	Renal disorder	14 (21.3%)
	Cardiovascular disorder	19 (29.2%)
	Liver disorder	20 (30.7%)
	Respiratory disorder	12 (18.4%)
2	Immunity	
	Compromised	52 (80%)
	Competent	13(20%)
3	Type of infection	
	Central line bloodstream infection	35 (53.8%)
	Catheter-associated urinary tract infection	15 (23.07%)
	Ventilator-associated pneumonia	15 (23.07%)
4	Site of cannulation	
	A vein in the femur	37 (56.9%)
	Basilic vein	15 (23.07%)
	Jugular vein	13 (20%)
5	Duration of medical device used	
	More than 12 days	45 (69.2%)
	Less than 12 days	20 (30.7%)
6	Duration of hospital stay	
	More than 7 days	57 (87.6%)
	Less than 7 days	8 (12.3%)
7	Survival rate	63 (96.9%)

The average age of the patients considered for this study was 43.5±5 years. Most of the patients in this study were male. From the history and clinical records it was found that most of the patients who suffered from medical device-associated infection had major renal disorder or cardiovascular disorders. The majority of patients suffering from infection had compromised immunity. Another important factor

observed during the study was that these patients had a longer duration of catheterization and had prolonged hospital stays. The most common route of cannulation in these patients was the femoral vein. Two patients under study who had ventilator-associated pneumonia did not survive. The characteristics of the patients who had medical device-associated infection is given in detail in Table No. 2.

Table no.3: The species isolated

Sr no.	Species	Frequency (%)
1	<i>Enterococcus faecalis</i>	4 (5%)
2	<i>Staphylococcus hominins</i>	5 (6.25%)
3	<i>Staphylococcus epidermis</i>	6 (7.5%)
4	<i>Staphylococcus aureus</i>	3 (3.75%)
65	<i>Staphylococcus capitis</i>	5 (6.35%)
7	<i>Klebsiella pneumoniae</i>	6 (7.5%)
8	<i>Stenotrophomonas maltophilia</i>	2 (2.5%)
9	<i>Acinetobacter baumannii</i>	5 (6.25%)
10	<i>Enterobacter cloacae</i>	6 (7.5%)
11	<i>Escherichia coli</i>	6 (7.5%)
12	<i>Pseudomonas aeruginosa</i>	5 (6.25%)
13	<i>Kocuria rhizophila</i>	2 (2.5%)
14	<i>Candida parapsilosis</i>	6 (7.5%)
15	<i>Candida albicans</i>	5 (6.25%)
16	<i>Candida glabrata</i>	4 (5%)

13 species of bacteria and 3 species of fungi were isolated from 65 patients. Among these patients, 80 pathogens were found. *Stenotrophomonas maltophilia* and *Enterobacter cloacae* were the common pathogens isolated from patients suffering from central line bloodstream infection. *Escherichia coli* and *Enterobacter cloacae* were isolated

from the patient suffering from catheter-induced urinary tract infection. Patients suffering from ventilator-associated pneumonia had most commonly *Klebsiella pneumoniae* and *S. maltophilia*. Table no.3 gives the frequency of the pathogens isolated from the patients.

Table No.4: Resistant bacteria and fungi

Sr no.	Resistant species	Frequency
1	Multidrug resistant bacteria	54 (67.5%)
2	Extended drug-resistant bacteria	20 (30.7%)
3	Carbapenem resistant species	28 (35%)
4	Extended-spectrum beta-lactamase-producing resistant species	10 (12.5%)
5	Amphotericin B and fluconazole resistant fungi	07 (8.75%)

The bacteria and fungi isolated were found resistant to certain drugs. 10 pathogens produced beta-lactamases and were resistant to beta-lactam drugs. 28 pathogens were resistant to carbapenem drugs. 54 pathogens were multi-drug resistant and 20 were extended-drug resistant species. 7 fungi isolated were resistant to amphotericin-B and fluconazole. The table no.4 gives the details of the resistant species.

DISCUSSION

The study included 110 patients suspected of having medical device-associated infections (MDAIs), and 65 were confirmed through positive culture tests. The infections were primarily central line-associated bloodstream infections (53.8%), followed by catheter-associated urinary tract infections (23.07%) and ventilator-associated pneumonia (23.07%). A total of 80 pathogens were isolated from the patients, including 55 bacterial and 25 fungal species. The most common bacterial species identified were *Enterococcus faecalis* (5%), *Klebsiella pneumoniae* (7.5%), and *Escherichia coli* (7.5%), while the most common fungal species were *Candida parapsilosis* (7.5%) and *Candida albicans* (6.25%).

The findings indicate that central line-associated bloodstream infections are the most prevalent MDAIs, reflecting the invasive nature of central venous catheters and the difficulty in preventing infections related to bloodstream entry. The high proportion of urinary tract infections and ventilator-associated pneumonia also highlight the vulnerability of patients with prolonged catheterization and mechanical ventilation. These infections pose significant clinical challenges due to the invasive nature of the devices and their susceptibility to biofilm formation by pathogens.

The study found that 67.5% of the bacterial isolates were multidrug-resistant (MDR), and 30.7% were extensively drug-resistant (XDR). Additionally, 35% of the bacterial species were resistant to carbapenems, a critical antibiotic class, and 8.75% of the fungal isolates were resistant to

amphotericin B and fluconazole. Notably, 10 pathogens produced extended-spectrum beta-lactamase (ESBL), further limiting treatment options.

The high rates of MDR and XDR pathogens, particularly carbapenem-resistant species, severely limit therapeutic options and increase the complexity of treating these infections. The presence of ESBL-producing pathogens further complicates management, underscoring the urgent need for infection control strategies and the development of new antimicrobials. The resistance to antifungal agents also emphasizes the growing threat of fungal infections, especially in immunocompromised patients.

The average age of the patients was 43.5 years, with a male predominance. Most patients had comorbidities, such as liver disorders (30.7%), cardiovascular diseases (29.2%), and renal disorders (21.3%), with 80% being immunocompromised. Additionally, 69.2% of the patients had medical devices in place for more than 12 days, and 87.6% had hospital stays longer than 7 days. Mortality was observed in two patients with ventilator-associated pneumonia.

The demographic profile indicates that middle-aged patients with significant comorbidities and compromised immune systems are particularly vulnerable to MDAIs. Prolonged use of medical devices and extended hospital stays further increase the risk of infection. The mortality in ventilator-associated pneumonia cases points to the severity of these infections and the need for aggressive management and preventive measures, especially in patients with complex health conditions.

Overall, the results highlight the substantial burden of MDAIs, particularly those caused by MDR and XDR pathogens, and the importance of implementing stringent infection control practices to mitigate the risks associated with prolonged device use.

In this study, it was found that 55.8% of the patients suffering from medical device-associated infections had central-line bloodstream infections. 22.8% of the patients suffering from infection had urinary tract infections, and

20% of them had ventilator-associated pneumonia. This proportion was found to be in line with other studies conducted with similar objectives [7, 8].

In this study amongst the other infections, central line-associated bloodstream infection has the highest proportion. As stated before the proportion of the infection vary from institute to institute. However, among the studies conducted recently in India, it is found that bloodstream infection is the most common medical device-associated infection [9,10]. Considering the fatality of the bloodstream infection it is necessary the investigate the underlying cause as the catheters are inevitable for the treatment of the patients.

Taking into consideration the resistant species, pathogens found resistant in this study are similar to the ones reported in the other study [11]. Although there are advances in treatment with antimicrobials the rate of development of resistance leads to constraints in treating the patients. Nevertheless, except for the resistant drugs the pathogens responded well to the other drugs such as colistin. In another study, the combination of ceftazidime, avibactam, and aztreonam was found to be effective in such species [12,13]. The mortality was reported in the patients with ventilator-associated pneumonia, they did not respond to the antimicrobial therapy. The *A. baumannii* and *K. pneumonia* were found in these patients. Similarly, another study reported Klebsiella pneumonia in a case of mortality due to medical device-associated pneumonia [14]. Mechanical ventilation is the last resort in several cases and pneumonia associated with it increases the complexities of the treatment [15].

GENERALIZABILITY

The generalizability of the study findings is limited due to its single-center design, reflecting local hospital practices and microbial resistance patterns specific to RIMS Ranchi. While the results highlight important trends in multidrug-resistant infections associated with medical devices, caution is needed when applying these findings to other healthcare settings, particularly in more developed regions. However, the study provides useful insights for similar resource-limited environments facing comparable challenges.

CONCLUSION

Complete elimination of the medical devices associated with infection is not possible. However, preventive measures to lower the incidence of bloodstream infection can improve treatment outcomes. Furthermore, analysis of the microbiological profile aids in narrowing it down to specific and effective treatments.

LIMITATION

The patients considered for the study were those whose catheters could be removed as per physicians' instructions. Also, due to laboratory limitations certain pathogens could not be isolated.

RECOMMENDATION

Preventative measures and the analysis of resistant pathogens are necessary to eliminate medical device-associated infection.

ACKNOWLEDGMENT

We would like to extend our heartfelt gratitude to the Department of Critical Care Medicine, RIMS Ranchi, for their invaluable support throughout the study. We also express our deep appreciation to the medical and nursing staff for their assistance in data collection and patient monitoring. Special thanks to the microbiology department for their efforts in conducting laboratory tests and providing critical insights into microbial resistance patterns. Finally, we are immensely grateful to the patients and their families for their participation and cooperation, without which this study would not have been possible.

ABBREVIATIONS

CLABSI- Central line-associated bloodstream infection
CAUTI- Catheter-associated urinary tract infection
VAP- Ventilator-associated pneumonia
MDAI- Medical device-associated infection

SOURCE OF FUNDING

No funding was received.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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