Original Article

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Study on Identification and Antibiotic Susceptibility Pattern of Microorganisms Responsible for Hospital-Acquired Infection in Patients with Indwelling Medical Devices

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ABSTRACT

Background: Hospital-acquired infections have a significant impact on public health issues. Hospital admitted patients with indwelling medical devices have a greater chance of developing nosocomial infections. The purpose of the study to determine the antibiotic suceptibility pattern of micro-organism and selection of appropriate drug for treating the cases of common medical device-associated infection.

Material and methods: This cross-sectional study was conducted in the Department of Microbiology, BIRDEM General Hospital from September, 2022 to August, 2023. A total of 112 cases of medical device-associated infection were enrolled during the study period. Endotracheal aspirates (50) urine (50) and blood (12) were collected from patients with Ventilator-Associated Pneumonia (VAP) Catheter-Associated Urinary Tract Infection (CAUTI) and Central Line-Associated Bloodstream Infection (CLABSI) respectively. Microorganisms were isolated and identified by culture and biochemical tests. Antibiotic susceptibility test was done using modified Kirby-Bauer disc diffusion method.

Results: From a total of 112 samples, nine different types of organisms were isolated including 33 (29.46%) E. coli, 22 (19.64%) Klebsiella, 30 (26.69%) Acinetobacter, 11 (9.82%) Pseudomonas and various others. Microorganisms showed highest resistance against ciprofloxacin while all of them were intermediate sensitive to colistin.

Conclusion: A wide range of microorganisms are responsible for medical device-associated infections with their higher rate of antimicrobial resistance. Identification of these microorganisms with their antibiotic susceptibility pattern helps in choosing the correct antibiotic therapy, thus decreasing the improper use of antibiotics.

KEY WORDS
Antibiotic sensitivity; Microorganisms; Hospital-Acquired Infections.

INTRODUCTION

Medical devices have become an integral part of hospital-based care but also predispose patients to more than 8,50,000 device-related infections annually. Epidemics of device-related infections appear to have increased in frequency since 1965, have been mainly due to Gram-negative bacilli but Gram-positive organisms are also responsible.[1] According to CDC (Centers for Disease Control) among 2 million healthcare-associated infections, 50% to 70% can be attributed to indwelling medical devices.[2] Medical device-associated infections are one of the most common and feared complications in medical practice. Devices predispose to infection by damaging or invading epithelial and mucosal barriers to infection, by supporting growth of microorganisms and thus serving as reservoirs. These infections usually have resulted from in-hospital contamination of devices and most often have been linked to urinary catheters, respiratory therapy equipment like endotracheal tube, intravenous infusion devices, hemodialysis catheters etc. The treatment of medical device-related infections is notoriously challenging and recurrence is common.[3,4]

Common medical device-associated infections occurring in a tertiary care hospital are: Ventilator Associated Pneumonia (VAP) Catheter Associated Urinary Tract Infection (CAUTI) Central Line Associated Bloodstream Infection (CLABSI).[5] Ventilator-Associated Pneumonia (VAP) is a nosocomial pneumonia found in 9% to 27% of patients on mechanically assisted ventilator. VAP can be defined

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as when the infection occurs after 48h of intubation, there is appearance of a new or progressive radiographic infiltrate and presence of at least two of the following criteria: Fever >38°C, leukocytosis or leucopenia and purulent secretions.[6] The endotracheal tube provides an ideal opportunity for bacterial adhesion and biofilm formation on both its inner luminal and outer surface.[7] About 86% of nosocomial pneumonia is associated with ventilation.[8] Another common medical device-associated infection in hospitals is Catheter-Associated Urinary Tract Infection (CAUTI). It is the most common type of nosocomial infection globally.[9] Central Line-Associated Bloodstream Infection (CLABSI) is the deadliest infection among medical device-associated infections which has a death incidence rate of 12% to 15%.[10]

Medical devices such as urinary catheter, intravenous catheter, endotracheal tube etc. are essential for management of many hospitalized patients. But these devices are frequently associated with various nosocomial infections by microorganisms showing higher rate of antibiotic resistance and antimicrobial resistance is a recent burning issue globally. So, infection caused by those organisms is an extra burden for patients as it prolongs hospital stay, raises expenses and increases morbidity and mortality of patients as well. Thus, identification ofresponsible organisms, determining their antibiotic susceptibility pattern can be very much helpful in selection of appropriate antimicrobial drugs for treating the cases of common medical device-associated infections.

MATERIALS AND METHODS

A cross-sectional observational study was carried out in the Department of Microbiology, BIRDEM General Hospital from September, 2022 to August, 2023. The study was approved by the Institutional Review Board, BIRDEM General Hospital (BIRDEM/IRB/2022/334). A purposive type of sampling technique was used. Sample size was determined to 204. Due to time constraint and scarcity of cases, 112 samples were collected including 50 endotracheal aspirates, 50 urine samples and 12 blood samples were collected from cases of Ventilator Associated Pneumonia (VAP) Catheter Associated Urinary Tract Infection (CAUTI) and Central Line Associated Bloodstream Infection (CLABSI) respectively. Appropriate Standard Operating Procedures (SOP) were followed for collection and handling of the specimens. Sample processing, culture and species identification was performed according to Good Clinical Laboratory Practice (GCLP) as described in CLSI 2022 annuals. Organismswere tested for the antimicrobial susceptibility by disc diffusion method following modified Kirby-Bauer techniqueagainst commercially available antimicrobial discs.

RESULTS

A total of 112 clinical isolates from 112 patients with medical device-associated infections were tested for their abilities to form biofilm during the study period at BIRDEM General Hospital, a tertiary care hospital in Dhaka city. Samples along with relevant data were collected from patients admitted in different wards of BIRDEM Hospital including ICU, CCU, medicine and allied wards.

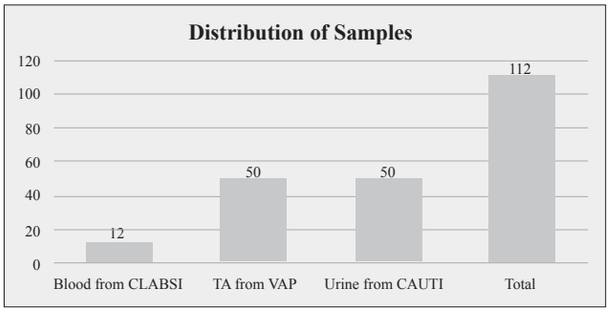

Figure 1 Distribution of samples collected from cases of medical device-associated infections

Figure 1 shows the distribution of samples collected from cases of medical device-associated infections in BIRDEM General Hospital, Dhaka. Out of 112 samples, 50 (44.64%) endotracheal aspirates were collected from patients with VAP, 50 (44.64%) urine samples were collected from patients with CAUTI and 12 (10.72%) blood samples were collected from patients with CLABSI.

Table I Pattern of isolated organisms from cases of medical device-associated infections

Isolated Organisms	Clinical specimens No. (%)			Total No. (%)
	TA	Urine	Blood	
Gram Negative				
E. coli	0 (0)	27 (54)	06 (50)	33 (29.46)
Klebsiella	13 (26)	06 (12)	03 (25)	22 (19.64)
Acinetobacter	29 (58)	01 (02)	0 (0)	30 (26.79)
Pseudomonas	06 (12)	03 (06)	02 (16.67)	11 (9.82)
Enterobacter	0 (0)	0 (0)	01 (8.33)	01 (0.89)
Gram Positive				
Enterococcus	0 (0)	09 (18)	0 (0)	09 (8.04)
Group B *Streptococcus*	0 (0)	02 (04)	0 (0)	02 (1.79)
Staphylococcus aureus	01 (02)	0 (0)	0 (0)	01 (0.89)
Candida albicans	01 (02)	02 (04)	0 (0)	03 (2.68)
Total	50 (100)	50 (100)	12 (100)	112 (100)

Note: Figure within parenthesis indicates percentage
No. = Number
TA = Tracheal Aspirate.

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Table I shows the pattern of isolated organisms from cases of medical device-associated infection in BIRDEM General Hospital, Dhaka. Gram negative organisms were predominant over Gram positive organisms. Out of 112 isolates, 97 (86.61%) were Gram negative and 15 (13.39%) were Gram positive organisms. E. coli was 33 (29.5%) in number which was the most prevalent among all isolates. Acinetobacter was isolated 30 (26.8%) in total followed by 22 Klebsiella (19.6%), 11 Pseudomonas (9.8%) and 1 Enterobacter (0.9%). Among Gram positive organisms, 9 Enterococcus (18%) were highest in number followed by 3 Candida albicans (2.7%) 2 Group B Streptococcus (1.8%) and 1 Staphylococcus aureus (0.9%).

Table II Demographic profile of patients with medical device-associated infection

Variables	No. of cases (n=112)
Gender	
Male	50 (44.64)
Female	62 (55.36)
Age	
Mean ± SD	56 ± 8.5
Range(years)	26 – 75

Table II shows the demographic profile including gender and age among the cases. 50 (44.64%) male and 62 (55.36%) female patients with a mean age of 56±8.5 (Range: 26 to 75 years) were found infected.

Table III Analysis of risk factors for developing medical device-associated infection

Risk factors	No. of cases (n=112)	Odds Ratio (OR)	p-value
Comorbidities			
Diabetic	91 (81.25)	10.55	0.004
Non diabetic	21 (18.75)		
Duration of devices			
< 05 days	49 (43.75)	7.34	<0.001
> 05 days	63 (56.25)		

Table III shows the risk factors fordeveloping medical device-associated infection. Comorbidity like diabetes mellitus (OR= 10.55, p-value <0.004) showed a significant impact on developing infection. Prolonged duration (>5 days) of indwelling devices (OR=7.34, p-value <0.001) was found to be a statistically significant risk factor for biofilm formation.

Table IV Antimicrobial resistance pattern among organisms causing medical device-associated infection (n=112)

Antimicrobial Drugs	Resistance Pattern
Imipenem	42/50 (84)
Ceftriaxone	40/50 (80)
Ceftazidime	49/50 (98)
Cefixime	40/42 (95.2)
Cefotaxime	40/42 (95.2)
Cefuroxime*	08/12 (66.67)
Gentamicin	48/52 (92.3)
Netilmicin	37/40 (92.5)
Amikacin	44/52 (84.6)
Nitrofurantoin*	05/21 (23.8)
Piperacillin+Tazobactam	46/50 (92)
Aztreonam	38/42 (90.5)
Ciprofloxacin	60/60 (100)
Cotrimoxazole	37/50 (74)
Colistin	0 (0)

* Used only in urine samples.

Table IV shows the antimicrobial resistance pattern among organisms causing medical device-associated infection. Organisms showed highest resistance against ciprofloxacin (100%) followed by ceftazidime (98%) cefotaxime (95.2%) cefixime (95.2%) netilmicin (92.5%) gentamicin (92.3%) piperacillin+tazobactam (92%) aztreonam (90.5%) ceftriaxone (80%) amikacin (84.6%) imipenem (84%) and cotrimoxazole (74%). All of the isolates were intermediate sensitive to colistin.

DISCUSSION

Health care-associated infections from invasive medical devices are major threat to patients' safety all over the world.[11] Various indwelling medical devices like urinary catheter, endotracheal tubes, central line catheters etc, act as the nidus for developing healthcare-associated infections.[12]

In the present study, 112 cases of medical device-associated infections (VAP, CAUTI and CLABSI) were investigated and samples were collected during the study period from BIRDEM General Hospital, Dhaka. Out of 112 samples, 50 (44.64%) endotracheal aspirates were collected from patients with VAP, 50 (44.64%) urine samples were collected from patients with CAUTI and 12 (10.62%) blood samples were collected from patients with CLABSI (Figure 1). Out of 50 TA samples from cases of VAP, all of the samples (100%) were collected from ICU, out of 50 urine samples from cases of CAUTI, 25 (50%) samples were collected from ICU, 10 (20%) samples from CCU and 15 (20%) samples were collected from other wards; out of 12

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blood samples from CLABSI cases, 7 (58.33%) samples were collected from ICU and rest 5 (41.67%) samples were collected from medicine and allied wards of BIRDEM General Hospital, Dhaka.

In this study, Gram negative organisms were predominant over Gram positive organisms. Out of 112 isolates, 97 (86.61%) were Gram negative and 15 (13.39%) were Gram positive organisms. Similar data were documented in several previous studies.[13,14] A study in England found Gram positive cocci more prevalent than Gram negative bacilli in cases of VAP, CAUTI and CLABSI.[3] They described Coagulase-Negative Staphylococci (CNS) C. albicans more prevalent followed by Acinetobacter, Pseudomonas, Klebsiella etc. But most of the researches carried out in Southeast Asia including Bangladesh, found Gram negative organisms predominant.[10,15] According to their studies, poor hygienic conditions, inadequate waste disposal from health care settings, prolonged stay in intensive care unit with prolonged use of antibiotics were the risk factors.

The pattern of isolated organisms from cases of medical device-associated infections were different in this study (Table I). Table I shows, Acinetobacter (58%) was the most prevalent organism followed by Klebsiella (26%) Pseudomonas (12%) Staphylococcus aureus (2%) and Candida albicans (2%) in 50 TA samples collected from patients with VAP. This finding was in agreement with anotherarticle.[16]

Out of 50 urine samples from cases of CAUTI, the isolation rate was: E. coli (54%), Enterococcus (18%), Klebsiella (12%) Pseudomonas (06%) Group B Streptococcus (04%), Candida albicans (02%) and Acinetobacter (02%). Similar isolation rate of different organisms was found in previous study.[17]

Out of 12 samples from cases of CLABSI yielded significant growth of E. coli (50%) Klebsiella (25%) Pseudomonas (16.7%) and Enterobacter (8.3%). A study taken place in Indiafound Pseudomonas the most common pathogen along with some Gram positive organisms causing CLABSI.[18] Another studyfound E. coli the most prevalent which is a similar to our findings.[19] But in this study, we found Gram positive organism was not associated with CLABSI while another study found Gram positive bacteria also responsible.[20] It might be due to our small sample size, use of broad spectrum antibiotics prior to sample collection and another possible reason can be the geographical variation like climate. In hot and humid climate of Bangladesh, Gram negative organisms are more pathogenic.

In the present study, demographic variation of patients with medical device-associated infection was evaluated (Table II). Out of 112 cases, 50 (44.64%) were male and 62 (55.36%) were female. The mean age of cases was 56 ± 8.5 ranging from 26 years to 75 years. Age was not found to be a significant risk factor for medical device-associated infection in this study.

Among 112 organisms, 91 (82.25%) pathogens were isolated from patients having type 2 diabetes mellitus. DM (OR=10.55, p-value <0.004) was found to be significant risk factors for developing infection as odds ratios were >1 and p-value <0.05 at 95% CI (Table III).

Parameters like gender and age correlated with the findings from a recent study which reported similar data but they found no significance of DM in developing infection.[21] The dissimilarity was probably due to most of the cases in our study was diabetic.

Another significant risk factor for infection was prolonged duration of indwelling devices (OR=7.34, p-value <0.001) [CI=95%]. The longer the duration of indwelling devices, the greater the chance of biofilm formation. This statement was in accordance with the above-mentioned study.[21]

The pattern of antimicrobial resistance among the microorganisms causing medical device-associated infection is highly complex (Table IV). All of the organisms (100%) were resistant to ciprofloxacin. No organism showed resistance to colistin. In contrast, another study also observed 100% colistin sensitivity among the organisms but the study reported maximum resistance to ceftazidime.[22] Levofloxacin was used instead of ciprofloxacin in above mentioned study. In this study, ceftazidime resistance was also high which was 98%. Resistance to other cephalosporins was also higher including ceftriaxone (80%) cefixime (95.2%), cefotaxime (95.2%) and cefuroxime (66.67%). The resistance of organisms was also high against all other antibiotics that including cotrimoxazole (74%) piperacillin+tazobactum (92%) and resistant to aztreonam (90.5%) and aminoglycosides. The patterns of antimicrobial resistance were similar to the patterns described in other studies conducted earlier.[23,24,25]

LIMITATION

- All demographic data of patients like primary diagnosis, previous antibiotic history could not be recorded properly.
- Polymicrobial infections could not be evaluated.
- Sample size of CLABSI was small due to time constraint and catheter tip culture could not be tested in CLABSI cases.

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CONCLUSION

Nine different species of microorganisms were found responsible for hospital-acquired infection in patients with indwelling medical devices. Among them, Gram negative organisms (86.61%) were predominant over Gram positive organisms. E. coli was the most frequent organism isolated from cases of CAUTI and CLABSI while Acinetobacter spp. was the highest in VAP cases. The rate of developing infection was significantly higher among the patients with prolonged duration (>5 days) of indwelling devices. All of the organisms were resistant to ciprofloxacin and the rate of resistance against other antibiotics was also high except for colistin.

RECOMMENDATION

- Routine surveillance for microorganisms responsible for hospital-acquired infections should be done for selection of appropriate treatment and infection control measures.
- Further research on a large number of hospital related isolates should be done to explore the connection between genetic background based on microbial subtyping.

DISCLOSURE

All the authors declared no competing interest.

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