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Surveillance of Medical Device - Associated Infections in a Tertiary Care Teaching Hospital, Indore, India

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A B S T R A C T

Ventilator associated pneumonia (VAP), intravascular catheter-related blood stream infections (CR-BSI) and catheter associated urinary tract infection (CA-UTI) are major medical device-associated infections that pose the greatest threat to patient safety. As surveillance of Healthcare-associated infections (HAI), so as to define the magnitude and nature of the problem, is the primary step towards reducing the risk of infection in vulnerable hospitalized patients, in the present study, surveillance of medical device associated infections (MDAI) was conducted. Surveillance of three common medical device-associated infections like CA-UTI, CR-BSI, and VAP was done. For the purpose of surveillance the definitions of CDC's National Nosocomial Infections Surveillance (NNIS) system criteria, were used. The overall rate of MDAI was 6.8 cases per 1000 device associated days. CAUTI (6.9%) was the most common MDAI whereas the rate of CR-BSI (8.1 cases per 1000 catheter days) was high among all MDAI studied. *Klebsiella* spp. (33.6%) followed by *E. coli* (21.3%) and *Pseudomonas* spp. (14.7%) were pathogens from MDAI. *Candida* spp. was isolated from 15 (11.4%) cases. *Pseudomonas* spp. (50%) was the major pathogen isolated from VAP cases. *Klebsiella* spp. was commonest isolate from CA-UTI and CR-BSI. The cost of MDAI is substantial, both in terms of morbidity and in terms of financial resources expended. To improve patient outcome and reduce health-care costs, strategies should be implemented to reduce the incidence of these infections. Surveillance is an effective tool that can be used to improve infection prevention and control practices.

Introduction

Healthcare-associated infections (HAI) are one of the most common adverse, iatrogenic events experienced in patient care. These infections As per National Health Safety Network (NHSN), HAI are can be defined as localized or systemic conditions that results from adverse reactions to the presence of an infection agent(s) or its toxin(s) and that was not present or incubating at the time of hospital admission (CDC, 2017). HAI are acquired by the patients while receiving healthcare treatment for other ailments or

conditions. Usually these infections become evident 48 hours or more after admission to the healthcare center. At times, HAI may become evident even after discharge of patient from healthcare setup.

Globally, every year HAI affect hundreds of millions patients. In developed countries, HAI concern 5-15% of hospitalized patients and can lead to complications in 25-50% of those admitted in intensive care units (ICU) (Eggimann and Pittet, 2001). HAI often lead to serious illness, prolonged hospital stay, induce long-term term disabilities, add incrementally to cost expected of the patient's underlying diseases alone (Deorukhkar and Saini, 2016). Additionally HAI negatively affects families of patients and contribute to a massive and added financial burden on the health-care system.

Although, HAI have a propensity to strike in any patient care area of a healthcare setup, its incidence is significantly higher in specialized units to cater for the critically ill patients, neonates, transplant recipients and burn patients. Various factors like increasing incidence of hospitalization, better adaptation of microorganisms to the hospital environment, advancement in medical technology along with injudicious use of antibiotics contribute to exponentially to HAI (Deorukhkar and Saini, 2016).

Nearly half of HAI are associated with indwelling medical devices (Kojic and Darouiche, 2004). Ventilator associated pneumonia (VAP), intravascular catheter-related blood stream infections (CR-BSI) and catheter associated urinary tract infection (CA-UTI) are major medical device-associated infections that pose the greatest threat to patient safety (Singh *et al.,* 2010). As surveillance of HAI, so as to define the magnitude and nature of the problem, is the primary step towards reducing the risk of infection in vulnerable hospitalized patients, in the present study, surveillance of medical device associated infections (MDAI) was conducted.

Materials and Methods

The present descriptive cross sectional study was conducted at Department of Microbiology of Index Medical College Hospital & Research Centre, Indore (MP) for a period of 1 year (June 2017 to June 2018). Surveillance of three common medical device-associated infections like CA-UTI, CR-BSI, and VAP was done. For the purpose of surveillance the definitions of CDC's National Nosocomial Infections Surveillance (NNIS) system criteria, were used (CDC, 2017).

Following methods and formulae were used for surveillance of CA-UTI, CR-BSI, and VAP.

CA-UTI: The patient was labeled as a case of CA-UTI, when he/she had an indwelling urinary catheter (IUC) in place for > 2 calendar days or if IUC was removed the day before the date of even and develops one or more of the following conditions: temperature (≥38°C), urgency and suprapubic tenderness (CDC, 2017; Deorukhkar and Saini, 2016).

With all aseptic precautions, urine sample was obtained from sampling port of indwelling urinary catheter with sterile syringe and needle. The sample was transferred to sterile container and immediately transported to the laboratory. The urine sample was inoculated on blood agar and MacConkey's agar incubated at 35°C for 24h. Additionally, a Gram stained smear prepared from uncentrifuge urine was also examined (Deorukhkar and Saini, 2016).

When urine culture showed growth with no more than two bacterial species and at least

one of which was ≥ 10^5 colony forming units (CFU) /mL, the organism was identified up to species level as per standard microbiological profile.

CA-UTI rate was expressed as the number of CA-UTI per 1000 catheter days and was calculated using the following formula:

$$\left(\frac{\text{Number of patients developing CA-UTI}}{\text{Total number of catheter days}}\right) \text{X1000}$$

CR-BSI: The CR-BSI was suspected when a patient with central venous catheter (CVC) in place for more than two consecutive calendar days developed fever other symptoms of sepsis of unknown origin (CDC, 2017; Deorukhkar and Saini, 2016).

Paired blood samples for culture were aseptically collected from such patients. The first blood sample was obtained from the catheter itself and the second from the other arm. Specimens for blood culture were obtained at the time of CVC removal. The CVC was removed by the critical care physician following all aseptic precautions and the distal 2 cm segment of the CVC was collected in sterile container with the help of sterile scissor. Inoculated blood culture bottles and CVC tip were immediately transported to the microbiology laboratory. Blood cultures samples were processed as per standard microbiological protocol (Deorukhkar and Saini, 2016). The CVC tip was processed as per semi-quantitative method described by Maki *et al.*, (1977). A colony count >15CFU/plate was considered significant. Isolation of the same bacterial species from CVC tip and blood culture indicated CR-BSI (Maki *et al.*, 1977).

CR-BSI rate was expressed as the number of CR-BSI per 1000 device days and was calculated using the following formula:

$$\left(\frac{\text{Number of patients developing CR-BSI}}{\text{Total number of CVC days}}\right) \text{X1000}$$

VAP: VAP was suspected when mechanically ventilated patients (for at least 4 calendar days) developed a new fever, cough, and purulent expectoration. On radiological examination there was evidence of a new or progressive pulmonary infiltrate and leukocytosis (CDC, 2017; Deorukhkar and Saini, 2016).

Any one of the purulent respiratory secretions like bronchoalveolar lavage (BAL), endotracheal aspirate, lung tissue and protected specimen brush were collected in sterile container and transported to the laboratory. Specimens were inoculated on to blood agar and MacConkey's agar. The plates were incubated at 35°C for 24 h (CDC, 2017; Deorukhkar and Saini, 2016).

A colony count ≥10^4 CFU/mL (for BAL and lung tissue), protected specimen brush ≥10^3 and ≥10^5 CFU/mL (for endotracheal aspirate) were considered as significant.

VAP rate was expressed as the number of VAP per 1000 device days and was calculated using the following formula:

$$\left(\frac{\text{Number of patients developing VAP}}{\text{Total number of ventilator days}}\right) \text{X1000}$$

Results and Discussion

During the study period, a total of 2478 patients were on different types of medical devices for a total duration of 21136 days. As shown in table 1, urinary catheter was most common indwelling medical device. During the study period, out of 2478 patients with indwelling medical devices, a total of 143

(5.8%) developed medical device associated infections (MDAI). The overall rate of MDAI was 6.8 cases per 1000 device associated days.

As shown in table 2, CAUTI (6.9%) was the most common MDAI whereas the rate of CR-BSI (8.1 cases per 1000 catheter days) was high among all MDAI studied.

Microbiological profile of MDAI is shown in table 3. *Klebsiella* spp. (33.6%) followed by *E. coli* (21.3%) and *Pseudomonas* spp. (14.7%) were pathogens from MDAI. *Candida* spp. were isolated from 15 (11.4%) cases (Table 3). Pseudomonas spp. (50%) was the major pathogen isolated from VAP cases. *Klebsiella* spp. was commonest isolate from CA-UTI and CR-BSI.

Surveillance is an effective tool that can be used to improve infection prevention and control (IPC) practices and decrease HAI. As per Bonita *et al*., (2006) health surveillance is defined as "the ongoing systematic collection, analysis, and interpretation of health data for planning, implementing and evaluating public health activities" (Bonita *et al*., 2006) Various researchers have reported that health care setups with effective and efficient surveillance and robust IPC programs have reduced HAI (Deorukhkar and Saini, 2016; Singh *et al.*, 2010).

In the present study, a total of 2478 patients were on different types of medical devices. Medical devices are considered to play a key role in the delivery of quality health-care to the masses.

However these indwelling medical devices may lead to infection. MDAI are often more treatment resistant and associated with fatal complications (Deorukhkar and Saini, 2016).

During the study period, a total of 143 (5.8%) developed medical device associated infections (MDAI). Various studies have reported the rate of infection associated with indwelling medical devices ranging from 4.9 to 8.5% (Singh *et al.*, 2010).

The overall rate of MDAI was 6.8 per 1000 device associated days. The rate of MDAI was higher than that reported by Singh *et al*., (2010) and Deorukhkar *et al*., (2016) whereas it was low as compared to Moreno *et al*., (2006); Vonberg *et al.*, (2006) and Habibi *et al*., (2008). In the study of Rosenthal *et al*., (2006) MDAI was found to be as high as 30.3 per 1000 device associated days.

Rate of MDAI highly varies as per healthcare setup and type of patient-care area. Various factors like duration and type of indwelling medical device, compliance with hand hygiene and standard precautions, and institution of care bundles also determine the rate of MDAI in a healthcare setup.

In the current study, urinary catheter was most common indwelling medical device. Nearly 12-16% of adult inpatients will have indwelling urinary catheter at some time during their hospitalization (McGuckin, 2012; Lo *et al.*, 2014). Presence of indwelling catheter is the leading cause of urinary tract infections (UTI). Chances of CA-UTI increases with each day of indwelling urinary catheter (McGuckin, 2012; Lo *et al.*, 2014).

A total of 132 patients with indwelling urinary catheter developed CA-UTI. The overall rate of CA-UTI was 6.9% or 7.2 cases per 1000 catheter days. A study conducted in 55 ICUs of 8 developing countries reported the rate of CA-UTI in a range of 1.7 to 12.8 cases per 1000 catheter days. CA-UTI may lead to complications like prostatitis, epididymitis, orchitis, cystitis, pyelonephritis, bacteremia, endocarditis, vertebral osteomyelitis, septic arthritis, endophthalmitis and meningitis (Scott, 2009).

Intravascular catheters are indispensable in modern-day medical practice, particularly in ICUs.

Although such catheters provide necessary vascular access, their use puts patients at risk for local and systemic infectious complications (local site infection, CR-BSI, septic thrombophlebitis and endocarditis) and other metastatic infections (lung abscess, brain abscess, osteomyelitis and endophthalmitis) (Mermel, 2000).

In the present study, a total 124patients were on intravascular catheters. Out of these 7 developed CR-BSI. The rate of CR-BSI was 5.6% or 8.1 per 1000 catheter associated days. The rate of CR-BSI was within the range reported from ICUs of 8 developing countries (7.8 to 18.5 cases per 1000 catheter associated days) (Rosenthal *et al.,* 2006).

In the study from Gujarat, Singh *et al*., (2010) reported the rate of CR-BSI was 0.16% or 0.48 per 1000 device days. The incidence of CR-BSI varies considerably by type of catheter, frequency of catheter manipulation and patient-related factors like underlying disease and its acuity (Mermel, 2000).

A mechanical ventilator is lifesaving equipment that provides temporary respiratory assistance to patients who cannot breathe of their own because of illness, trauma, congenital defects or drugs.

During the study period, a total of 463 patients were on mechanical ventilator support. Out of these, only 4 developed VAP.

The rate of VAP was 0.8% or 2 cases per 1000 ventilator associated days. The rate of VAP was lower than other Indian studies (Deorukhkar and Saini, 2016; Singh *et al.,* 2010). VAP remains a major challenge in the ICU. Various national and international studies have reported the range of VAP between 1 to as high as 52.7 cases per 1000 ventilator days (Singh *et al*., 2010).

In the present study, *Klebsiella* spp. (33.6%) followed by *E. coli* (21.3%) and *Pseudomonas* spp. (14.7%) were pathogens from MDAI. Similar observation was noted by other Indian researchers like Singh *et al*., (2010).

Although the type of pathogen varies as per healthcare setup, the microorganisms isolated from HAI cases are usually the nosocomial pathogens prevalent in the hospital environment (Deorukhkar and Saini, 2016; Singh *et al.,* 2010). Therefore IPC measures like hand hygiene, barrier use, skin preparation practices and disinfection policy should be strictly followed.

In recent years, fungi in general and *Candida* in particular are increasingly implicated in HAI. *Candida* spp., rank 3rd among various leading cause of catheter-associated infections (Deorukhkar and Saini, 2016; Seneviratne *et al.,* 2008).

Candida spp. can colonize and form biofilm on almost all medical devices in current use. In the present study, a total of 16 (11.2%) *Candida* spp. were isolated from MDAI. *Candida* MDAI are highly treatment resistant and may lead to serious life-threatening complications (Seneviratne *et al.,* 2008).

A total of 15 *Candida* spp. were isolated from CAUTI cases. Candiduria is rarely noted as a community acquired infection in a healthy individual with structurally normal urinary tract (Kojic and Darouiche, 2004). Indwelling urinary catheters, diabetes mellitus, advanced age, female sex, use of immunosuppressive agents and broad spectrum antibiotic treatment are important risk factors for candiduria (Deorukhkar and Saini, 2016; Kojic and Darouiche, 2004).

Table.1 Indwelling medical devices and device days.

Indwelling medical device	Number of Patient	Number of device days
Urinary catheter	1891	18348
Central venous catheter	124	865
Ventilator	463	1923
Total	2478	21136

Table.2 Medical device associated infections.

Medical device associated infection (MDAI)	Number of patient with indwelling medical device	Device associated days	Number of patient developing MDAI (%)	Rate of MDAI per 1000 device associated days.
CA-UTI	1891	18348	132 (6.9)	7.2
CR-BSI	124	865	07 (5.6)	8.1
VAP	463	1923	04 (0.8)	2
Total	2478	21136	143 (5.8)	6.8

Table.3 Microbiological profile of medical device associated infections

Microorganism	CA-UTI (%)	CR-BSI (%)	VAP (%)	Total (%)
E. coli	32 (24.2)	01 (14.3)	-	33 (23.1)
***Klebsiella* spp.**	43 (32.6)	04 (57.1)	01 (25)	48 (33.6)
***Pseudomonas* spp.**	19 (14.4)	-	02 (50)	21 (14.7)
Staphylococcus aureus	13 (9.8)	01 (14.3)	-	14 (9.7)
***Acinetobacter* spp.**	04 (3.1)	-	01 (25)	05 (3.5)
***Proteus* spp.**	06 (4.5)	-	-	06 (4.2)
***Candida* spp.**	15 (11.4)	01 (14.3)	-	16 (11.2)
Total	**132**	**07**	**04**	**143**

Candida spp. are the commonest cause of systemic mycoses. This fungal genera is the third leading cause of blood stream infections (BSIs) in patients admitted to ICUs and the number three cause of CR-BSI (Deorukhkar and Saini, 2016). In the present study, *Candida* spp. was isolated from 1 (14.3%) case of CR-BSI. In the study of Deorukhkar *et al.*, (2016), a total of 3 *Candida* spp. were isolated from 9 cases of CR-BSI (Deorukhkar and Saini, 2016). Similarly Mansur *et al.*, (2014) and Kaur *et al.*, (2015) also reported isolation of *Candida* spp. from CR-BSI cases (Mansur *et al.*, 2014; Kaur *et al.*, 2015). The cost of MDAI is substantial, both in terms of morbidity and in terms of financial resources expended. To improve patient outcome and reduce health-care costs, strategies should be implemented to reduce the incidence of these infections.

Surveillance is an effective tool that can be used to improve infection prevention and control practices. As the rate of medical device associated infections (MDAI) vary greatly as per type of healthcare setup and patients cared for, the surveillance data of particular institute cannot be generalized

similarly the generalized data cannot reflect the situation of a particular institute. This surveillance study helped us to generate internal benchmarks for MDAI.

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