

Surveillance of Device-Associated Infections in Critical Patient Care Areas

Mumtaz Ahmad Khan

Pathology Department, Azad Jammu and Kashmir Medical College, Azad Jammu and Kashmir University, Muzaffarabad

Abstract

Objectives: To determine Device-associated infections (DA-HAIs) rates, microbiological profiles and resistance patterns of infecting organisms in intensive care units and step down unit of a tertiary care hospital in Saudi Arabia.

Study Design: Prospective descriptive study.

Place and duration of study: The study was carried out at King Abdullah Hospital Bisha, Kingdom of Saudi Arabia over a period of 12 months from January to December 2011.

Materials and Methods: A prospective, active DA-HAI surveillance study was conducted in criticalcare patient areas from Jan 2011 to Dec 2011. The rates of ventilator-associated pneumonia (VAP), central catheter-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI) were calculated along with microbiological profile, and antimicrobial resistance.

Results: Surveillance data was obtained by trained infection control professionals using standard CDC criteria for HAIs.

From January through December 2011, a total of 129 DA-HAIs were reported: 74 (57.36%) were cases of VAP, 34 (26.35%) were cases of CAUTI, and 21 (16.29%) were cases of CLABSI.

Conclusion: Increase rates of DAIs emphasize the need to improve infection control practices and management of invasive device in hospital. In critical patient areas, ongoing surveillance programs and implementation of quality improvement projects could contribute to reducing HAIs.

Key words: Healthcare associated infections, nosocomial infection, ventilator-associated pneumonia, and health-care-associated.

Introduction

Health care-associated infections (HAIs) are infections that patients acquire while receiving treatment for medical or surgical conditions and are the most frequent adverse event during care delivery.¹

Health care-associated infections have been associated with substantial morbidity and attributable mortality, as well as greatly increased health care costs. The CDC estimates that HAIs account for 2 million infections and 90,000 deaths annually.²

HAIs from invasive medical devices in the intensive care

unit are major threat to patient safety. In a report from the National Nosocomial Infection Surveillance (NNIS) system now called as NHSN, involving data from 498 998 patients, 83% of episodes of nosocomial pneumonia were associated with mechanical ventilation, 97% of urinary tract infections arose in patients with a urinary catheter in place, and 87% of primary bloodstream infections were in patients with a central line.³

Past Studies showed that an integrated infection control program that includes surveillance of health care-associated infections can reduce the incidence of infection by as much as 30%.⁴

Medical devices are responsible for a large portion of nosocomial infections, particularly in critically ill patients. In this population of patients, 95% of cases of urinary tract infection are catheter related, 87% of cases of bloodstream infection originate from an indwelling vascular catheter, and 86%

Correspondence: Dr. Mumtaz Ahmed Khan
Microbiology department, Azad Jammu and Kashmir Medical College,
Muzaffarabad
Email: mumtazahmad8166@gmail.com

of cases of pneumonia are associated with mechanical ventilation.⁵ These devices provide a pathway for microorganisms from the environment to enter the body, facilitate the transfer of pathogens from one part of the patient's body to another, and act as inanimate foci where pathogens can proliferate protected from the patient's immune defences.⁶ Device-associated health care-associated infections affect the quality of care in intensive care units, increasing patients' morbidity and mortality and the costs of patient care.⁷

Hand hygiene, isolation practices and surveillance are the most important steps in controlling HAIs. Surveillance provides data that allow the determination of endemic infection rates, early detection of epidemics, and assessment of the efficacy of interventions.⁸

Several studies suggest that conducting organized surveillance and control programs can reduce HAI rates significantly. Following recommendations from the Centers for Disease Control and Prevention's (CDC) National Nosocomial Infections Surveillance System (NNIS), a targeted surveillance by focusing on device-associated infections (DAIs) in intensive care units (ICUs) had been carried out in many hospitals, particularly in the US.⁹

However, surveillance data regarding DAIs are limited in most developing countries. The aim of the present study is to determine DA-HAIs rates, microbiological profiles and resistance patterns of infecting organisms in intensive care units and step down unit of a tertiary care hospital in Saudi Arabia.

Materials and Methods

The study was carried out at King Abdullah Hospital, Bisha over a period of 12 months from January 2011 to December 2011. King Abdullah Hospital, Bisha, is a 400-bed referral center in Bisha region in Kingdom of Saudi Arabia. The critical patient areas consist of capacity of 13 bedded intensive care units (ICU), 13 bedded intermediate care unit (IMCU) and 24 bedded neonatal intensive care unit (NICU). There are 5 isolation rooms in the ICU and IMCU. Severely ill medical and surgical patients, except for neonates are candidates for admission in ICU. The average monthly bed occupancy rates of ICU, IMCU and NICU are 85%, 87% and 92% respectively. Patients with road traffic accidents, sepsis, respiratory tract infections, and those undergoing surgery for complicated diseases comprise the usual patient population for ICU. The patient and nurse ratio in these units is 1:3 for patients on ventilators and 1:1 for others.

The targeted Surveillance study was conducted in the ICU, IMCU and NICU by hospital infection control team. Our infection control team is consisting of four infection control practitioners and a chief of infection control who is qualified medical microbiologist. All the team is full time working for hospital infection control. They were given three independent offices with internet access. An infection control practitioner visits all patients on medical devices daily. All patients admitted in critical patient areas during the study period from January 2011 to December 2011 with a length of stay of more than 48 hours were enrolled in the study. They were followed-up until 48 hours after discharge. Demographic data including the age and gender, underlying diseases, admission date to hospital and the ICU, diagnosis at admission, risk factors for HAIs, physical examination findings, laboratory results, culture results, and susceptibility data, and antibiotics administered during the ICU follow-up were collected and recorded using standardized record cards. The number of patients in ICUs, patient-days and device days for ventilators, urinary catheters, and central lines were recorded by using specialized forms. In non-NICU locations, the device-days consist of the total number of central line-days, urinary catheter-days, or ventilator-days. In NICU locations, the device-days consist of the total number of central line-days and umbilical catheter-days, or ventilator-days. The HAIs were defined according to the standard definitions of the CDC.¹⁰

Patients with signs and symptoms of infection in the first 48 hours of the hospital stay were not considered as having HAIs and excluded from the study. If a urinary tract infection (UTI), pneumonia or blood stream infection (BSI) was associated with the use of a catheter, ventilator, or a central line, the diagnosis of a DAI was established. Although all healthcare associated infections were recorded, only results of DAIs are presented in this study.

Device utilization ratios were calculated by dividing the total number of device-days by the total number of patient-days. The DAI rates for pneumonia, UTI, and BSI were calculated by dividing the total number of DAIs by the total number of device-days and multiplying the result by 1000.¹¹

The infections resulted from medical devices were compared with NHSN data¹¹. Cultures were taken from respiratory specimens, blood and urine depending upon identifiable focus of infection. Initially strains were identified based on the morphological behavior of the isolates on various differential media. The specimens were inoculated on appropriate media. Organism's identification and antibiotic susceptibility

testing were done by using BD Phoenix Automated Microbiology system (Becton Dickinson, Maryland, USA). Clinical Laboratory Standards (CLSI) interpretive criteria were used for susceptibility results. Susceptibility testing was performed using the modified Kirby- Bauer disk diffusion method by using Muller Hinton Agar for antibiotics, which were not on the Phoenix panels (colistin, and tigecycline). The results were expressed as susceptible/resistant according to Clinical Laboratory Standards (CLSI) interpretive criteria.¹²

Quality control was performed by using reference strains of *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853 to confirm consistency of materials, methods, and results.

WHONET Version 5.6 was used for compilation and calculation of data of bacterial isolates.

Results

From January through December 2011, a total of 129 DA-HAIs were reported: 74 (57.36%) were cases of VAP (figure 1), 34 (26.35%) were cases of CAUTI (figure 2), and 21 (16.29%) were cases of CLABSI (figure 3).

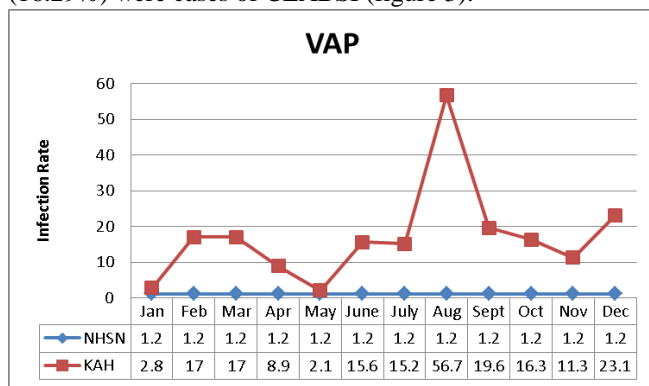


Figure 1: Ventilator associated pneumonia (VAP) rates for the year 2011

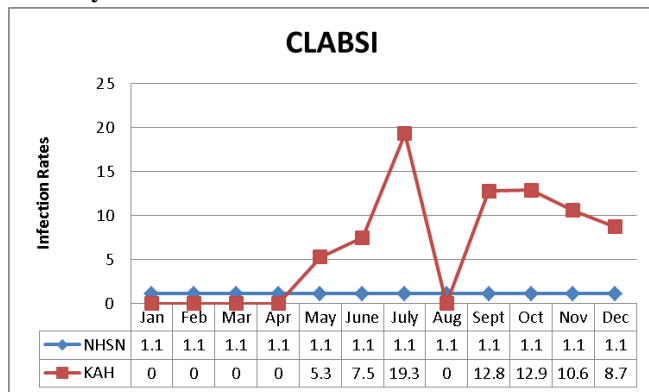


Figure 2: Central line associated blood stream infection (CLABSI) rates for the year 2011.

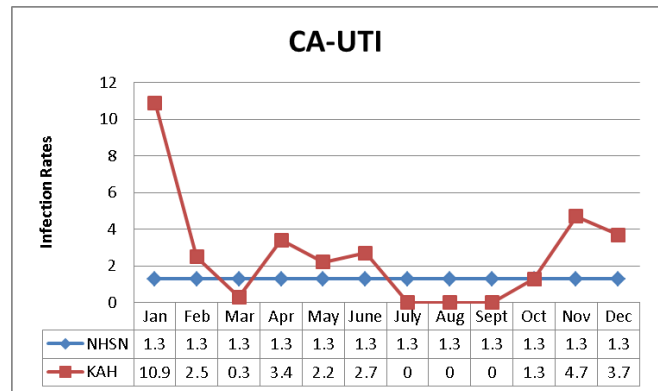


Figure 3: Catheter associated urinary tract infection (CA-UTI) rates for the year 2011

The mean overall DAI rates were 16.38 for VAP, 2.64 for CAUTI, and 2.01 for CLABSI infections per 1000 device-days. The total number of patient-days during the surveillance period was 86042. The mean overall DAI rates were 17.13 for VAP, 2.64 for CAUTI, and 6.42 for CLABSI infections per 1000 device-days. The mean overall device use ratios were 0.69 for ventilators, 0.16 for central lines, and 0.38 for urinary catheters.

Most device-associated HAIs were reported from ICU 92 (71.31%) followed by neonatal ICU 19 (14.72%) and step down unit 18 (13.95%) (Table 1).

Table 1. Distribution of DA-HAIs, stratified by type of Patient care area

Type of PCA	Overall	VAP	CLABSI	CA-UTI
ICU	92(71.31%)	51(39.53%)	16(12.40%)	25 (19.37%)
IMCU	18(13.95%)	7(5.42%)	2 (1.55%)	9 (6.97%)
NICU	19 (14.72%)	16(12.40%)	3(2.32%)	0
Total	129 (100%)	74(57.36%)	21(16.29%)	34(26.35%)

From 129 cases of DA-HAI, a total of 162 pathogenic isolates were recovered and reported. The frequencies of Gram-positive, Gram negative bacteria and *Candida* spp were 27.77 % (n=45), 65.43% (n=106) and 6.80% (n=11), respectively. *Acinetobacterspp* (25.92%), *Klebsiellaspecies* (12.96%) and *E coli* (11.11 %) were the most common isolates among Gram negative organisms, while *Staph. aureus* and *Coagulase-negative staphylococci* (CoNS) were the two leading Gram positive isolates. Polymicrobial etiology was

also observed in some case of VAP and CA UTI. Isolated microorganisms are presented in Table 2.

Table 2. Distribution of selected pathogens associated with DA-HAIs

Pathogen	Number(%) of isolates
Staph. aureus	26(16.04%)
Methicillin-resistant Staph aureus(MRSA)	8(4.93% among all isolates and 31% among all Staph isolates)
Coagulase Negative Staphylococci(CoNS)	11(6.80%)
Acinetobacterspp	42(25.92%)
Klebsiellaspp	21 (12.96%)
E.coli	18 (11.11 %)
Enterobacterspp	13 (8.02%)
Pseudomonas aeruginosa	3 (1.85%)
Stenotrophomonasmaltophilia	2 (1.23%)
Enterobacterspp	2 (1.23%)
Other gram negative	5(3.08%)
Candida spp	11 (6.80%)
total	162 (100%)

Table 3 shows the percentage of antibiotics resistance in Gram-positive and Gram-negative isolates resistant to the antibiotics tested. 31% of the isolated *S aureus* were found methicillin resistant. Both methicillin resistant *Staph. aureus* and *Coagulase-negative staphylococci* were showed no resistance to vancomycin. 30% *Acinetobacterspp* were found resistant to imipenem. 62 % (n=26) of all *Acinetobacter species* were found Multidrug- Resistant and 5% (n=2) *Acinetobacterspecies* were found pan resistant (resistant to all antibiotics including colistin). Because of limited supply of colistin disk, we used it only for the *Acinetobacter* isolates. 8% of isolated *Klebsiella* were found resistant to imipenem. All other enterobacteriaceae were showed no resistance to imipenem. For *Pseudomonasaeruginosa*, the resistance rates for imipenem was found 21%. 34% of *Klebsiellaspecies* and 28% of *E coli* were found Extended-spectrum beta-lactamase (ESBL) producers. For *Klebsiella species* and *E coli* ESBL production was found 34.2% and 28.6% respectively. *Acinetobacter*, *Klebsiella*, *E coli*, *Enterobacter* and *Candida* were the most common isolates from sputum and urine. *Coagulase negative staphylococci* was the most frequent isolate from blood culture.

Table 3. Antibiotic resistance patterns of the most frequently isolated pathogens

Microorganisms	Resistance pattern	Resistant isolates %
Staphylococcus aureus	Methicillin resistance	31%
Coagulase-negative staphylococci	Methicillin resistance	72 %
Acinetobacterspecies	Carbapenem resistance	30%
	Colistin resistance	5%
Pseudomonas species	Carbapenem resistance	21%

Klebsiellaspecies	ESBL production	34%
	Carbapenem resistance	8%
Escherichia coli	ESBL production	28%
	Carbapenem resistance	0%

Discussion

Device associated infection rates: The VAP and CLABSI rates in our ICUs were found to be many folds higher than the pooled mean rates reported by the National Healthcare Safety Network (NHSN)¹³, and the CA-UTI rate was also slightly higher.

National Healthcare Safety Network is the CDC's most widely used healthcare-associated infection (HAI) tracking system. NHSN provides facilities, states, regions, and the nation with data needed to identify problem areas, measure progress of prevention efforts, and ultimately eliminate healthcare-associated infections. Beginning decades ago with 300 hospitals, NHSN now serves more than 12,000 medical facilities tracking HAIs.

Mean overall DAI rates for VAP, CLABSI and CAUTI were found to be 17.13, 6.42 and 2.64 in this study. However, these rates lower than *Tutuncuet al* who described the mean overall DAI rates for VAP, CLABSI and CAUTI, and as to be 26.5, 17.6 and 8.3.¹⁴

In addition, VAP, CLABSI and CAUTI, and rates were 20.7, 9.7 and 13.6 in the study by In an et al.¹⁵

Our DAI rates are comparable to those previously reported from KSA and developing countries. As most of the cases in ICU are admitted with head injuries resulted from road traffic accidents, depressed consciousness and impaired protective oropharyngeal reflexes pose a major risk for the development of VAP in neurologic patients.¹⁶

The VAP rates for patients followed in N-ICUs were reported to be 20.4 and 27.4 in 2 different studies from Germany.¹⁷

In our study VAP ranged between 0-56.7, CLABSI 0-19 and CAUTI 0-10.9 infections per 1000 device-days. Published data revealed VAP rates between 10.3-19.9, CAUTI rates between 4.5-8.5, and CLABSI rates between 0.9-13.1 per 1000 device-days in neurosurgical ICUs.¹⁸

For very high rates of VAP, a quality improvement projects like FOCUS-PDCA were launched to decrease these infections. FOCUS-PDCA is an acronym for Find, Organize, Clarify, Understand, Select, Plan, Do, Check and Act. After implementation of this project we observed a marked decrease in VAP rates in ICUs.

During study period, our CLABSI and CA-UTI rates remained zero for many months. It means that we can achieve

a zero targets for such infections by strict adherence to infection control guidelines.

Several factors may have contributed to these high DAI rates. Our hospital is a reference hospital with more than 400 beds. It was shown that large-sized medical centers tend to have higher healthcare-associated infection rates.⁹ Under staffing and a low nurse-patient ratio are frequently reported problems in developing countries.¹⁹ The total nurse patient ratio in our ICUs was lower than has been recommended.²⁰ Inadequate infrastructure (for example insufficient bed area in IMCU), non adherence to hand hygiene and under implementation of bundle precautions for medical devices may have increased our DAI rates. The lack of long-term care facilities in KSA may extensively prolong the ICU follow-up in some instances and leads to longer lengths of stay, which in turn increase the likelihood of the development of recurrent HAIs.

Better implementation of infection control measures, reducing the utilization of invasive devices by using alternative methods, continuous education of healthcare workers, improving compliance with published guidelines, and implementing ventilator bundles, central lines bundles, and urinary catheter bundles can help to improve our DAI rates.

Microbiological and Resistance findings: The organisms most frequently recovered from our ICU were Gram-negative bacteria, with the most common being *A. baumannii*, *Klebsiella* spp and *E. coli*. The common bacterial pathogens were found to be similar to the outcomes reported in some of the other countries in the Middle East.²¹ The most common Gram-positive organisms recovered from our ICU were *S. aureus* and coagulase-negative *Staphylococcus*. Among these, 31% of the isolated *S. aureus* and 72% of the *Coagulase-negative staphylococci* (CoNS) were methicillin resistant. This MRSA rate was similar to that reported by Mark E Jones *et al.* during a surveillance study from a French ICU.²²

In our study *Acinetobacter* spp accounted 42 (25.92 %) of all isolates and out of these 80% found to be MDR and 5% were found pan-drug-resistant. These findings are consistent with the study performed by Seifert *et al.*²³

A Spanish study²⁴ has shown that *Acinetobacter* isolates, usually acquired in the ICU, are multidrug resistant and may cause severe infections associated with a high mortality rate. It is an important source of nosocomial septicemia, pneumonia, and urinary tract infections.²⁵

Because of emergence of multidrug-resistance and pandrug-resistance associated with *Acinetobacter* spp, the role of

preventing spread of this pathogen to other patients is paramount. The recently released Centers for Disease Control and Prevention (CDC) infection control recommendations indicate that hospitals with increased rates of multidrug-resistant *Acinetobacter* should take more aggressive infection control measures to control and prevent further nosocomial transmission.²⁶

ESBL-Producing *Klebsiella pneumoniae* has been increasing incrementally since 2005. The incidence of 34% in our study is lower than previous reports from Saudi Arabia.²⁷

ESBL-producing isolates should be reported as resistant to all penicillins, cephalosporins, and aztreonam.²⁸ Carbapenems are the treatment of choice for serious infections due to ESBL-producing organisms.

Our study results regarding antibiotic resistance are in agreement with reports from other countries that have shown high antimicrobial resistance rates in ICU patients.^{29, 30}

Our ICU shows much higher resistance rates. Extended use of inappropriate antimicrobials leads to the emergence of MDR species, which are extremely difficult to treat. These findings also suggest other possibilities for our high resistance rates, such as inappropriate, uncontrolled empiric therapy or cross acquisition of resistance rather than the development of natural resistance. These reasons justify the need for establishing prompt infection control strategies in hospitals with special consideration in critical patient care areas. We must seriously consider implementation of the strategies recommended by the Centers for Disease Control and Prevention to prevent antimicrobial resistance in health care settings, which are: prevent infection, diagnose and treat infection effectively, use antimicrobials wisely and prevent transmission of infection.

In conclusion, we observed considerably high rates of VAP and CLABSI in our ICUs when compared with the NHSN data. In addition, we noted high rates of resistance among pathogens frequently encountered in DAIs. These findings emphasize the need to improve infection control practices and management of invasive device use in our hospital. In critical patient areas, ongoing surveillance programs and implementation of quality improvement projects such as FOCUS-PDCA as we did, could contribute to reducing HAIs.

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