Device-associated Infections (DAIs) in ICU: Using new CDC/ NHSN definitions

Mostafa Mohammadi[1], Arash Seifi[2], Maryam Mokhtaryan[3], Azam Ghahan[4], Sara Ghaderkhani[3], Esmaeil Mohammadnejad[5], Reza Ghanei Gheshlagh[6]

[1]Associate Professor, Department of Anesthesiology and Critical Care, School of Medicine, Tehran University of Medical Science, Tehran, Iran, [2]Assistant Professor , Department of Infectious Diseases, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran, [3]Department of Infectious Diseases, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran, [4]Department of Nursing, Imam Khomeini Hospital, Tehran University of Medical Sciences, Tehran, Iran, [5]Assistant Professor of Nursing, Department of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran, [6]Assistant Professor, Social Determinants of Health Research Center, Research Institute for Health Development, Kurdistan University of Medical Sciences, Sanandaj, Iran

Abstract

Surveillance of device-associated infections (DAIs) in intensive-care units (ICUs) is essential for a suitable healthcare strategy-planning. This study was conducted to determine the DAIs rate, microbial epidemiology, and antimicrobial resistance pattern (AMR) in ICU. Three major DAIs, ventilator associated pneumonia (VAP), catheter-associated urinary tract infection (CAUTI), and central line-associated bloodstream infection (CLABSI) were assessed prospectively during 6 months (2018 March 21 to September 22) in an 18-bed ICU of a tertiary teaching hospital in Tehran according to new CDC/NHSN definitions for surveillance of DAIs. The incidence of VAP, CAUTI, and CLABSI were 38.2, 8.9, and 13.5 per 1000 device-days respectively. The most organisms were *Acinetobacter baumannii* (34.9%), *Klebsiella pneumonia* (19%), *E.coli* (10.7%), *Candida* (10.7%), *Enterococcus Spp.* (8.7%), *Pseudomonas aeruginosa* (8.7%), and *Staphylococcus aureus* (2.9%). Klebsiella pneumoniae carbapenemase (KPC)-producing was 47.4%. Acinetobacter resistance to Ampicillin-sulbactam and carbapenems was 80.6% and more than 90% respectively. *Methicillin resistant Staphylococcus aureus* (*MRSA*) was 66.6% and *Vancomycin-resistant Enterococcus* (*VRE*) was 88.9%. This study showed high incidence of DAIs and resistant organisms in the ICU. Preventive measures are essential to decrease the rates.

Key words: *Device associated infection; antimicrobial resistance; intensive care unit*

Introduction

Health care-associated infection (HAI) is an infection occurring in a patient during the process of care in a hospital or other health care facility which was not present or incubating at the time of admission [(1,2)]. About 10% of patients admitted to hospitals are suffered from HAIs [(3)].

Corresponding Author:
Esmaeil Mohammadnejad,
Address: South second Floor, No. 5, Mohammadi Alley, North Eskandari St, Tehran, Iran., Email: asreno1358@yahoo.com, Tel: +98-2166936626, Fax: +98-2166936626

In intensive care units (ICUs), the commonly reported infections are ventilator-associated pneumonia (VAP), catheter-associated urinary tract infection (CAUTI), and central line-associated bloodstream infection (CLABSI) resulting in high mortality [(4,5)]. In low and middle income countries, the frequency of hospital infections in ICU is 2-3 times higher than in high-income countries, and use of devices is much higher than in the United States [(4,6)].

Considering resistant microorganisms, hospital environments are the largest sources of *vancomycin resistant enterococci* (VRE), *Methicillin-resistant Staphylococcus aureus* (MRSA), and multidrug resistance (MDR) gram negative bacilli like *Klebsiella*

pneumoniae; so the microbial epidemiology should be investigated and monitored [4,7].

In developing countries such as Iran, there are some limitations in accurate detection of infections, causative agents, and antimicrobial resistance [8]. For the importance of HAIs and the antibiotic resistance patterns of microorganisms, this study was conducted to determine the DAIs rate, microbial epidemiology, and AMR in a general ICU in a tertiary collegiate hospital in Tehran, Iran.

Material and Method

In this study, 629 patients admitted to the general ICU from 21 March 2018 to 22 September 2018 were studied and analyzed for HAIs according to Center for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN) case-definitions [2]. Information of the patients affected with infections was recorded according to declaration of Helsinki on medical research ethics [9]. In a pre-defined form designed to collect data, the patients' demographic information, infection types, cultures results, and denominators (patient-days, ventilator days, central-line days, and urinary catheter days) were recorded. Finally, the rate of DAIs and microbial epidemiology were assessed based on the data coded on the questionnaire and entered into the SPSS software version 24. To display quantitative information, mean ± SD is used and prevalence is indicated for qualitive variables.

Results

The study was conducted in an 18-bed general ICU during a 6-month period in 2018. In this duration 692 patients were admitted which 385 (56%) were male and 307 (44%) were female.

The study showed that 103 patients (14% of all ICU admission) were infected with DAIs. Infection subtypes included VAP (53 cases, 51.5% of DAIs), CAUTI (27 cases, 26.2% of DAIs) and CLABSI (23 cases, 22.3% of DAIs). The patient-days were 3212 for this time period. Device-days were as follows: 1386 ventilator-days, 3018 urine-catheter-days, 1698 central-line-days. Device associated infection (DAI) rate or density was calculated for each subtype. This rate for VAP, CAUTI, and CLABSI per 1000 device-days was 38.7, 8.9, and 13.5 respectively (Table 1).

Table 1: Device-associated infection (DAI) rate/density, and device utilization ratio (UR).

	Frequency (No.)	Patient-days	Device-days	DAI Rate/Density	Device UR
VAP	53	3212	1386	38.7	0.43
CAUTI	27	3212	3018	8.9	0.94
CLABSI	23	3212	1698	13.5	0.53

VAP: ventilator-associated pneumonia; CAUTI: catheter-associated urinary tract infection; CLABSI: central line-associated bloodstream infection; UR: utilization ratio

The number of crude mortality among infected patients for VAP, CAUTI, and CLABSI was 27, 15 and 12 patients. According to these total 54 deaths (of 103 HAIs) the crude mortality rate was calculated to be 52%. Among causative agents, gram positive cocci in 14 cases (13.6%), gram negative bacilli in 78 cases (75.7%) and 11 candida isolates (10.7%) were reported (Table 2). And the patterns of antimicrobial resistance (AMR) demonstrate in Table 3.

Table 2: Prevalence of microorganisms in each DAI group.

		Microorganism	BSI No(%)	UTI No(%)	VAP No(%)	Total No(%)
Gram Positive		Staphylococcus aureus	1 (4.3%)	0 (0%)	2 (3.8)	3 (2.9%)
		Streptococcus agalactiae	1 (4.3%)	0 (0%)	0 0%)	1 (1%)
		Enterococcus Spp.	8 (34.8%)	1 (3.7%)	0 (0%)	9 (8.7)
		Streptococcus pneumonia	0 (0%)	0 (0%)	1 (1.9%)	1 (1%)
Gram Negative	Enterobacteriacea	Escherichia coli	1 (4.3%)	7 (25.9%)	3 (5.7)	11 (10.7)
		Klebsiella pneumonia	3 (13.0%)	3 (11.1%)	13 (24.5)	19 (18)
		Proteus Spp.	0 (0%)	1 (3.7%)	0 (0%)	1 (1%)
		Enterobacter Spp.	0 (0%)	0 (0%)	2 (3.8)	2 (1.9)
		Pseudomonas aeruginosa	0 (0%)	2 (7.4%)	7 (13.2)	9 (8.7)
		Acinetobacter baumannii	7 (30.4%)	4 (14.8%)	25 (47.2)	36 (34.9)
Fungi		Candida Spp.	2 (8.7%)	9 (33)	0 (0%)	11 (10)
		Total	23 (100%)	27 (100%)	53 (100)	103 (100%)

Table 3: The patterns of antimicrobial resistance (AMR) in microorganisms.

Organism	No. of isolates	Antibiotic	Resistance No (%)
Staphylococcus aureus	3	Vancomycin	0 (0)
		Cefoxitin	2 (66.6)
		Clindamycin	2 (66.6)
Enterococcus spp	9	Ampicillin	4 (44.4)
		Vancomycin	8 (88.9)
		Linezolid	0 (0)
Klebsiella pneumonia	19	Imipenem	9 (47.4)
		Piperacillin-Tazobactam	14 (73.7)
		Ceftazidime	15 (78.9)
Escherichia coli	11	Imipenem	0 (0)
		Ceftriaxone	5 (45.4)
		Ciprofloxacin	5 (45.4)
Acinetobacter baumannii	36	Ampicillin-Sulbactam	29 (80.6)
		Imipenem	34 (94.4)
		Colistin	0 (0)
Pseudomonas aeruginosa	9	Amikacin	4 (44.4)
		Gentamicin	7 (77.8)
		Piperacillin-Tazobactam	4 (44.4)
		Ceftazidime	4 (44.4)
		Ciprofloxacin	4 (44.4)
		Imipenem	7 (77.8)

Discussion

In this study, we investigated the device-associated infections and the microbial pattern in a general ICU in a tertiary collegiate hospital in Tehran, Iran. The incidence for VAP, CAUTI, and CLABSI per 1000 device-days was 38.7, 8.9 and 13.5, respectively. According to the World Health Organization (WHO) report, the incidence for VAP, CAUTI, and CLABSI per 1000 device-days in developing countries is 23.9, 8.8, and 12.2[1]. Comparing with this report, the rate of VAP is clearly higher in our ICU. The reason might be failure to fully design and implement an appropriate bundle for infection control of VAP in the ICU. in the International Nosocomial Infection Control Consortium (INICC) report for DAIs in ICUs of 50 low- and middle-income countries, the incidence density for VAP, CAUTI and CLABSI per 1000 device-days was 13.1, 5.07 and 4.1 respectively[10]. In our study all DAIs rate were higher; might be for weakly implement of infection control components such as low hand hygiene compliance, inappropriate contact isolation, and etc. Afhami et al in a recent multi-center study in Tehran showed the rate of 21, 7.4, and 10.2 for VAP, CAUTI, and CLABSI in 1000 device-days[4]. According to that multi-center study, it seems even in compare with similar ICUs in our local region, the rate of VAP in our ICU is higher and we should consider more preventive and control measures.

For causative agents and antimicrobial resistance, this study showed that overally in DAIs gram negative bacilli like *Acinetobacter baumannii* and *Klebsiella pneumonia* were the most common organisms, and they were often multidrug resistance. In European Centers for Disease Control and Prevention (ECDC) report for ICUs, the most frequently isolated microorganism was Pseudomonas aeruginosa in pneumonia, coagulase-negative staphylococci in bloodstream infections, and Escherichia coli in urinary tract infections[11]. There was also in this report that 30% of *Staphylococcus aureus* isolates were oxacillin-resistant (MRSA). Resistance to third-generation cephalosporins was reported in 18% of *E. coli* isolates, 38% of Klebsiella spp. isolates and 32% of Enterobacter spp. isolates. Carbapenem resistance was reported in 11% of Klebsiella spp. isolates, 27% of *P. aeruginosa* isolates and 66% of Acinetobacter baumannii isolates [11]. Comparing with ECDC report, in our study drug-resistance was much higher, representing the necessity of paying more attention to AMR and planning to prevent creation of such resistant microorganisms and control the spread of them in our ICU. In INICC report, the same microorganisms reported but the resistance level was lower than in our study [10]. In Iran national report for 2015, the grams negative bacilli (like our study) were the dominant agents but the resistance patterns weren't reported[5]. Afhami et al in a recent multi-center study in Tehran reported *Acinetobacter baumannii* and *Klebsiella pneumoniae* as the major agents of DAIs (4) that in our study the result was so. To control and prevention of hospital infections and antibiotic resistance some measures should be taken in order to developing policies, controlling, evaluating conducted operations and Antibiotic stewardship.[12].

There were some limitations to this study. The ICU was in a tertiary collegiate hospital; therefore, the patients with severe underlying diseases managed and required more intensive care, so the infection rate in our study may have been higher than the overall rate in the region.

Conclusion

This study showed high incidence of DAIs and resistant organisms in the ICU. Preventive measures are essential to decrease the rates.

Ethical Clearance: This article is the result of a research project (General Practitioner) approved by the in Tehran University of Medical Science, Tehran, Iran. The information provided in this study is related to the research project approved by the Ethics Committee in Tehran University of Medical Science, Tehran, Iran.

Conflict of Interest: The author(s) declared no potential conflicts of interest.

Funding/Support: This research was financially supported by the Research Deputy of Tehran University of Medical Sciences.

References

1. The burden of health care-associated infection worldwide. Geneva: World Health Organization. Accessed January 2018. URL: https://www.who.int/gpsc/country_work/burden_hcai/en/
2. CDC/NHSN surveillance definitions for specific types of infections. Atlanta: Centers for Disease Control and Prevention. Accessed January 2018. URL: http://www.cdc.gov/nhsn/pdfs/pscmanual/17pscnosinfdef_current.pdf

3. Mohammadnejad E, Abbaszadeh A, Soori H, Afhami S.Prevention and control of nosocomial infections proceeding in intensive care units: A content analysis study. Acta Medica Mediterranea. 32(SpecialIssue4), 1295-1301.
4. Afhami Sh, Seifi A, Hajiabdolbaghi M, Bazaz NE, Hadadi A, Hasibi M, et al. Assessment of device-associated infection rates in teaching hospitals in Islamic Republic of Iran. Eastern Mediterranean Health Journal. 2019; 25(2):90-97.
5. Eshrati B, Masoumi Asl H, Afhami S, Pezeshki Z, Seifi A. Health care-associated infections in Iran: A national update for the year 2015. Am J Infect Control.2018;46:663-7
6. Allegranzi B, Nejad SB, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. The Lancet. 2011;377(9761):228-41.
7. Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009–2010. Infection Control & Hospital Epidemiology. 2013;34(1):1-14.
8. Seifi A, Dehghan-Nayeri N, Rostamnia L, Varaei S, Akbari Sari A, Haghani H, et al. Health care-associated infection surveillance system in Iran: Reporting and accuracy. Am J Infect Control. [In Press]. doi: 10.1016/j.ajic.2018.12.028.
9. Association WM. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. Jama. 2013;310(20):2191.
10. Rosenthal VD, Al-Abdely HM, El-Kholy AA, AlKhawaja SAA, Leblebicioglu H, Mehta Y, et al. International Nosocomial Infection Control Consortium report, data summary of 50 countries for 2010-2015: Device-associated module. Am J Infect Control. 2016 Dec 1;44(12):1495-1504.
11. Healthcare-associated infections acquired in intensive care units: Annual Epidemiological Report for 2016. European Centers for Disease Control and Prevention. URL: https://ecdc.europa.eu/sites/portal/files/documents/AER_for_2016-HAI.pdf
12. Kalantarzadeh M, Mohammadnejad E, Ehsani S R, Tamizi Z. Knowledge and Practice of Nurses About the Control and Prevention of Nosocomial Infections in Emergency Departments, Arch Clin Infect Dis. 2014 ; 9(4):e18278. doi: 10.5812/archcid.18278.