Jpn. J. Infect. Dis., 67, 5-8, 2014

Original Article

Device-Associated Nosocomial Infection Rates and Distribution of Antimicrobial Resistance in a Medical-Surgical Intensive Care Unit in Turkey

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(Received February 13, 2013. Accepted July 22, 2013)

SUMMARY: The aim of this study was to explore the rate of device-associated nosocomial infections (DANIs) and the distributions of causative agents and patterns of antibiotic resistance in the medical-surgical intensive care unit (ICU) over a 3-year period and to compare these rates with those reported by National Nosocomial Infections Surveillance System and International Nosocomial Infection Control Consortium. A total of 1,798 patients were hospitalized in our ICU for 13,942 days, of which 309 patients had DANIs, indicating an overall infection rate of 22.1 per 1,000 ICU-days. The central line-associated bloodstream infection rate was 6.4 per 1,000 catheter-days, whereas the ventilator-associated pneumonia rate was 14.3 per 1,000 ventilator-days and the catheter-associated urinary tract infection rate was 4.3 per 1,000 catheter-days. Overall, 87.4% of all *Staphylococcus aureus* DANIs were caused by methicillin-resistant strains. With respect to *Pseudomonas aeruginosa*, 30.9% of the strains were resistant to ciprofloxacin, 23.3% to amikacin, 43.1% to ceftazidime, 19.1% to piperacillin-tazobactam, and 34.7% to imipenem. Furthermore, 1.9% of the *Enterococcus* spp. were resistant to vancomycin, and 51.1% of *Enterobacteriaceae* were resistant to ceftriaxone. DANI rates decreased over the 3-year study period, which was likely in response to the infection control measures implemented in our ICU.

INTRODUCTION

Infections acquired in intensive care units (ICUs) are a major health concern, particularly in developing countries (1). Device utilization is responsible for high risk of infections, such as catheter-associated urinary tract infections (CAUTIs), central line-associated bloodstream infections (CLABSIs), and ventilator-associated pneumonia (VAP), in ICU patients (2–5). Surveillance is the most important component of infection control programs in hospitals; therefore, standards of institutional hospital-acquired infection (HAI) surveillance and infection control have been adopted by developed countries (6,7). The Centers for Disease Control (CDC) has implemented the National Nosocomial Infection Surveillance System (NNISS) to standardize HAI surveillance (8).

The objective of the present study were as follows: (i) to determine the 3-year device-associated nosocomial infection (DANI) rate, the distribution of causative agents and their rates of resistance to certain antibiotics in the medical-surgical ICU of our hospital between January 2008 and December 2010 and (ii) to compare these rates with those reported by NNISS in Turkey and the International Nosocomial Infection Control Consortium (INICC).

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METHODS

In the present study, we retrospectively evaluated patients who developed nosocomial infections and were treated in a 16-bed medical-surgical ICU affiliated with the anesthesiology and reanimation clinic of the Goztepe Training and Research Hospital (Istanbul, Turkey) between January 2008 and December 2010. A nosocomial infection was defined as an infection that developed 48 h after admission and up to 10 days after discharge from hospital in accordance with the CDC criteria (8).

Patient-days were described as the total number of days in the ICU, whereas device-days were described as the overall total number of days in the ICU over 1 year. The DANI rate was calculated using the following formula: DANI/patient-days $\times$1,000. The rate of device utilization was calculated as device-days/patient-days (9).

Urine, transtracheal aspiration, and blood samples from catheter tips and subcutaneous tissues were obtained from patients and cultivated on blood agar and eosin methylene blue agar plates. Bacterial identification and antibiotic susceptibility was determined by the Bauer–Kirby disc diffusion method (10).

The infection control program was implemented by the ICU infection control team since November 2007. Infection control seminars were regularly held every month, during which the importance of hand hygiene was emphasized. ICU staff were evaluated for compliance with hand hygiene on a regular basis by infection control nurses. Compliance with hand hygiene was eval-

uated during the following five instances: (i) before contact with the patient, (ii) before an aseptic procedure, (iii) after contact with body secretions, (iv) after contact with the patient, and (v) after contact with the patient's environment. Compliance of the ICU staff with washing hands using soap and water and scrubbing hands using antiseptic were evaluated monthly. When compliance was not achieved, the ICU staff were warned of the risk of infections by the infection control nurses. These observations related to compliance with hand hygiene were reported to the ICU chief by the infection control team. If a low level of compliance was observed, the number of seminars and observation frequency was increased by the infection control team.

Hand antiseptics were placed next to patient beds. The number of sinks in each ICU room was increased. Disposable gowns were worn before contact with patients infected with multidrug-resistant (MDR) pathogens and their environments. The beds and environments of MDR pathogen-infected patients were cleaned with 10% bleach by two different members of the cleaning staff.

Patients were cohorted following isolation of MDR pathogen. Contact isolation procedures were strictly enforced.

RESULTS

During the 3-year study period, 1,798 patients were hospitalized in the ICU for 13,942 days, of which 309 had DANIs. The overall DANI rate was 22.1 per 1,000 ICU-days. DANI distributions and device utilization ratios are listed in Table 1, whereas DANI distribution over the 3-year study period is shown in Fig. 1.

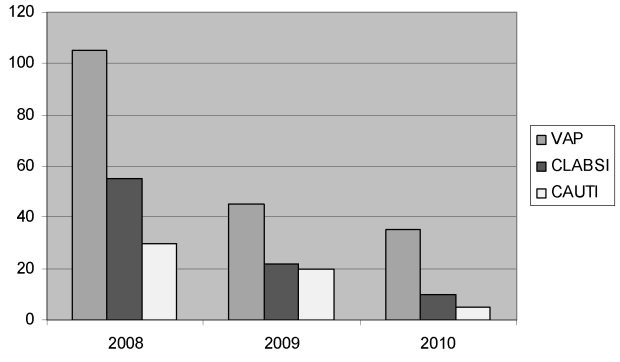

Fig. 1. The distribution of device-associated nosocomial infections over the 3-year period. VAP, ventilator-associated pneumonia; CLABSI, central line-associated bloodstream infection; CAUTI, catheter-associated urinary tract infection.

The overall VAP rate over 1,000 ventilator-days was 14.3% (range, 6.7%–21.8%) (Table 1). The causative pathogens included *Acinetobacter* spp. (24.8%), *Pseudomonas* spp. (34.3%), *Staphylococcus aureus* (10%), *Candida* spp. (7%), *Enterobacteriaceae* (15.3%), and other microorganisms (8.3%).

The overall CLABSI rate over 1,000 catheter-days was 6.4% (rang, 2.9%–10.5%) (Table 1). The causative pathogens included *Acinetobacter* spp. (14.2%), *Pseudomonas* spp. (9%), *S. aureus* (9%), coagulase-negative *Staphylococcus* (19%), *Candida* spp. (4.7%), *Enterobacteriaceae* (13%), *Enterococcus* spp. (10.7%), and other microorganisms (20.4%).

The overall CAUTI rate over 1,000 urinary catheter (UC)-days was 4.3% (rang, 1.03%–7.3%) (Table 1). The causative pathogens included *Pseudomonas* spp. (8.3%), *Candida* spp. (20%), *Enterobacteriaceae* (48.3%), *Enterococcus* spp. (16.6%), and other microorganisms (6.8%).

The overall rates of bacterial resistance are listed in Table 2, whereas the resistance rates of *Pseudomonas* spp. are listed in Table 3.

Table 2. Percentage of resistance rate for the 3-year period

Resistance	2008	2009	2010	NNISS–INICC
VRE	5.8	0	0	29–5
Ciprofloxacin-resistant *Pseudomonas*	29.4	26.9	36.4	29–59
Ceftriaxone-resistant *Enterobacteriaceae*	51.2	55.9	46.2	19–55
MRSA	84.6	77.8	100	59–84

NNISS, National Nosocomial Infection Surveillance System; INICC, International Nosocomial Infection Control Consortium; VRE, vancomycin-resistant *Enterococcus*; MRSA, methicillin-resistant *Staphylococcus aureus*.

Table 3. Antibiotic resistance rates and distributions according to NNISS report for *Pseudomonas* spp.

Antibiotic	Overall resistance (%)	NNISS (92–04) Percentile
Piperacillin-tazobactam	19.1	50–75
Ciprofloxacin	30.9	50–75
Imipenem	34.7	75–90
Ceftazidime	43.1	>90
Amikacin	23.3	NA
Meropenem	41.6	NA

NA, no data available for comparison.

Table 1. Device-associated infections per 1,000 days

Infection site	Device type	Device days	Device use	HAI	DANI (%)	Rate per 100 patients	Rate per 1,000 device-days
VAP	MV	11,746	0.84	169	54.6	9.3	14.3
CLABSI	CVC	12,331	0.88	80	25.8	4.4	6.4
CAUTI	Urinary catheter	13,794	0.98	60	19.4	3.3	4.3

HAI, hospital-acquired infection; DANI, device-associated nosocomial infection; VAP, ventilator-associated pneumonia; MV, mechanical ventilation; CLABSI, central line-associated bloodstream infection; CVC, central venous catheter; CAUTI, catheter-associated urinary tract infection.

DISCUSSION

Nosocomial infections are major causes of morbidity and mortality in ICU patients. Infection control programs that include intensive surveillance can reduce the incidence of these infections. NNISS and INICC databases are guides to compare nosocomial infection rates. DANIs comprise the major group of ICU infections; however, data regarding DANI rates are extremely limited in Turkey. Cetinkaya et al. (11) demonstrated that DANI rates in Turkey were 3–4-fold higher than those reported by NNISS.

In the present study, we evaluated DANI rates, device utilization rate, and distributions of bacterial isolates and their resistance patterns, and found a higher use of mechanical ventilation (MV) (0.84 versus [vs] 0.43), central venous catheter (CVC) (0.88 vs 0.57), and UC (0.98 vs 0.78) than those reported in the NNISS network (7). The overall CLABSI rate observed in the present study was higher than that reported by NNISS (6.4 vs 3.4 per 1,000 CVC-days). Similarly, in the present study, the overall VAP rate was higher than that reported by NNISS (14.3 vs 5.1 per 1,000 MV-days), whereas the CAUTI rate was similar to that reported by NNISS rate (4.3 vs 3.3 per 1,000 UC-days) (7).

A comparison of data from the present study and those from INICC revealed that the rates of invasive device use, VAP, CLABSI, and CAUTI were higher in the present study, which could be attributed to a combination of several factors. First, our hospital is a large training hospital. Richards et al. (12) demonstrated that tertiary training hospitals had both higher DANI rates and device utilization ratios compared with non-training hospitals. Second, treatment duration was long and treatment alternatives were complicated, because our ICU had patients had either with severe trauma or those who underwent neurological surgery for severe and chronic conditions.

Although the overall HAI rate per 100 patients (17%) observed in our study was higher than the rates reported by INICC (14.7%) and another study from India (1.5%), it was lower than the rate reported in a study from Thailand (23.1%) (13–15). The overall CLABSI rate (6.4 per 1,000 CVC-days) observed in our study was higher than that reported by NNISS (3.4 per 1,000 CVC-days) but lower than the overall data by INICC (12.5 per 1,000 CVC-days) (7,13). The overall VAP rate of 14.3 per 1,000 MV-days observed in our study was lower than that reported by Leblebicioglu et al. (26.5 per 1,000 MV-days) and INICC global rate (24.1 per 1,000 MV-days) but higher than the rate reported by NNISS (5.1 per 1,000 MV-days) (7,13,16). The CAUTI rate (4.3 per 1,000 UC-days) observed in this study was similar with the rate reported by NNISS (3.3 per 1,000 UC-days) and the overall INICC rate (4.2 per 1,000 UC-days) (7,13). The catheter utilization rate in our ICU was higher than the rate reported by the NNISS network (0.98 vs 0.77).

In the present study, the most frequently detected DANI agents for VAP were *Pseudomonas aeruginosa* and *Acinetobacter* spp. However, prolonged hospitalization increases the risk of infection with these pathogens. Our ICU comprises of rooms with multiple beds with no barriers between patients, and there is only one isolation room. *Candida* spp. were the most frequently reported isolates in urinary tract infections, primarily because of long duration of catheterization and the fact that most patients receive broad-spectrum antibiotics.

An increasing resistance rate of *P. aeruginosa* to ciprofloxacin has been shown in our study over the 3-year period. The overall resistance rate to ciprofloxacin observed in the present study was similar to that reported by NNISS but lower than the rate reported by INICC. Gikas et al. (17) reported a 22% resistance rate of *P. aeuruginosa* to ciprofloxacin, whereas Leblebicioglu et al. (16) found a rate of 51.1% from the evaluation of 13 ICUs in Turkey.

The resistance rate of *P. aeruginosa* to imipenem significantly increased (26.5%–54.5%) over the 3-year period in our study. In another Turkish study, the resistance rate to imipenem was reportedly 52% (18). Mehta et al. (19) reported 42% and 28.6% resistance rates of *Pseudomonas* spp. to imipenem and ciprofloxacin, respectively. In another study from Thailand, the resistance rate to ciprofloxacin was 39.3% and that to imipenem was 30.9% (20).

The percentage of methicillin-resistance *S. aureus* (MRSA) has increased over the 3-year study period and reached a resistance rate that was higher than those reported in Thailand (68%) and Cyprus (68.2%). The resistance rates to vancomycin among enterococcus isolates in our study were similar to those reported by Leblebicioglu et al. (16).

The reduction in the DANI rates over the 3 years is remarkable in our study, which may be explained by several factors. First, in our ICU, infections have been evaluated by one specific specialist from the Infectious Disease and Microbiology Department since 2008. Second, infection control measures have been applied more precisely, and infection control training has been gradually increased. In light of these developments, DANI rates have significantly decreased from 2008 to 2010. Increased resistance rates to carbapenem of *Pseudomonas* spp., MRSA, and MDR-*Acinetobacter* spp. are receiving attention for appropriate selection of antibiotics.

Conflict of interest None to declare.

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