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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Device-Associated Nosocomial Infections Developing in the Intensive Care Units: A Five-Year Evaluation

Yoğun Bakım Ünitelerinde Gelişen İnvaziv Araç İlişkili Hastane Enfeksiyonları: Beş Yıllık Değerlendirme

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ABSTRACT

Objective: We analyzed the rates of invasive device-associated nosocomial infections (IDANIs), ventilator-associated pneumonia (VAP), central venous catheter-related bloodstream infections (CVCR-BSI), catheter-associated urinary tract infections (CR-UTI) and their microorganism profiles.

Material and Method: Patients who were followed up in Konya Training and Research Hospital ICUs between 01.01.2016 and 31.12.2020 for a period of 5 years were included in the study. IDANIs were defined by the Centers for Disease Control (CDC) and the National Nosocomial Infections Surveillance Network (NNISN) criteria.

Results: Health-care associated infections (HCAIs) were detected in 1556 of the 34972 patients over the five-year period in ICUs.510 of the HCAIs were IDANIs. The rates of invasive device utilization were 0.28 for mechanical ventilators, 0.39 for central venous catheters and 0.85 for urethral catheters. The device-associated nosocomial infection rates for ventilator-associated pneumonia (VAP) 2.7%, central venous catheter-related bloodstream infections (CVCR-BSI) 17.9%, catheter-related urinary tract infections (CR-UTI) 12%. Of these infections, *Klebsiella pneumoniae* was the most frequent pathogen.

Conclusion: IDANIs are seen more frequently in intensive care units than in other units. Patients who developed IDANI had longer durations of ICU hospitalizations and more often had to use invasive procedures such as mechanical ventilators, central and urinary catheters.

Keywords: Health care–associated infection, invasive device-associated infection, ventilator-associated pneumonia

ÖZ

Giriş: Çalışmada, invaziv araç ilişkili hastane enfeksiyonları (İAİHE); ventilatör ilişkili pnömoni (VİP) santral venöz kateter ilişkili kan dolaşımı enfeksiyonu (SVKİ-KDE), kateter ilişkili üriner sistem enfeksiyonlar (Kİ-ÜSE) ve mikroorganizma profilinin değerlendirilmesi amaçlandı.

Gereç ve Yöntem: Çalışmaya Konya Eğitim ve Araştırma Hastanesi YBÜ'lerde 01.01.2016-31.12.2020 tarihleri arasında 5 yıllık zaman diliminde takip edilen hastalar dahil edildi. İAİHE tanıları Center for Disease Control and prevention (CDC), Ulusal Hastane Enfeksiyonları Sürveyans Ağı (UHESA) tanı kriterlerine göre koyuldu.

Bulgular: Yoğun bakım ünitelerinde 34972 hastanın beş yıllık takibinde 1556 sağlık hizmeti ilişkili enfeksiyon (SHİE) saptandı. Bu SHİE'lerin 510'u invaziv araç ilişkili hastane enfeksiyonu olarak saptandı. İnvaziv araç kullanım oranı; mekanik ventilatör 0,28, santral venöz kateter 0,39, üriner kateter 0,85 olarak hesaplandı. Ventilatör ilişkili pnömoni (VİP) %2,7, santral venöz kateter ilişkili kan dolaşımı enfeksiyonu (SVKİ-KDE) %17,9, kateter ilişkili üriner sistem enfeksiyonu (Kİ-ÜSE) %12 olarak saptandı. *Klebsiella pneumoniae* en sık rastlanan patojendi.

Sonuç: İAİHE yoğun bakım ünitelerinde diğer ünitelere göre daha sık görülmektedir. Mekanik ventilatör, santral kateter ve üriner kateter gibi girişimsel işlemlerin sık uygulanması ve uzun hastane yatışları İAİHE gelişiminde önemlidir.

Anahtar Kelimeler: İnvaziv araç ilişkili hastane enfeksiyonları, sağlık hizmeti ilişkili enfeksiyon, ventilatör ilişkili pnömoni

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INTRODUCTION

The preventability of health care-associated infections (HCAI) has a serious importance today because it causes high mortality and morbidity. HCAI is accepted as an indicator of quality. HCAI follow-up will determine that each unit will create unique data and will ensure that there is comparable data all over the world (1). Invasive device-associated nosocomial linfections (IDANIs) are seen more frequently in intensive care units than in other units due to frequent interventional procedures and suppression of the immune system due to serious illness (2,3).

IDANI has serious effects on mortality and morbidity, in addition, it increases the length of stay of patients and increases the cost of the hospital. Increasing technology, high risk diseases, long life expectancy, increase in invasive procedures increase the need for intensive care units of hospitals. For this reason, intensive care units are places where the use of invasive vehicles is high, which makes hospital infections very important in such risky units.

In order to establish an effective infection control in health institutions, each center should determine its own hospital infection rate and distribution, microorganisms that make up the hospital flora, and resistance patterns (1,4,5). Intensive care units (ICUs) also constitute a large part of surveillance as the units where hospital infections are most common. IDANI surveillance is recommended for monitoring and comparing infection rates in the ICU (6-8). The aim of this article; to evaluate the IDANIs that developed in Konya Training and Research Hospital ICUs between 2016-2020, to reveal the current situation of the hospital, to determine new strategies by reviewing infection control measures, and to increase our patient care and treatment quality.

MATERIAL AND METHOD

In this study, patients over 18 years of age who were followed up by the infectious diseases departmen in Konya Training and Research Hospital intensive care units between 01.01.2016 and 31.12.2020 for a period of 5 years were included. Our hospital has a total of 19 intensive care units and 157 intensive care beds. 34972 patients were followed up with the active prospective surveillance method on a total of 154084 hospitalization days.

The study was approved by local ethics committee, dated on 04th March 2021 and with the registration number of E-86737044-806.01.03.

Blood, catheter, urine, tracheal aspirate and bronchoalveolar lavage cultures appropriate for the physical examination findings were accumulated from the cases. The blood and sterile samples obtained were incubated in the fully-automated blood culture device of BACTEC 9240 (Becton Dickinson, Diagnostic Instrument System, Spark, USA). The specimens likely to reproduce were inoculated from the tubes onto the media of eosin methylene-blue (EMB) agar and 5% sheep blood agar. All petriplates were incubated at 35±2°C for 24 hours in aerospace environment. The colonies of isolated bacteria not fermenting lactose and having negative oxidase test results were identified using the VITEK 2 Compact® (BioMérieux, France) device, and the antibiotic susceptibilitiesof these bacteria were investigated under the criteria of The Informational Supplements to the Clinical and Laboratory Standards Institute (CLSI) (9). Ventilator-associated pneumonia (VAP), central venous catheter-related blood stream infections (CVCR-BSI), catheter-related urinary tract infection (CR-UTI) were defined according to the diagnostic criteria of Centers for Disease Control and Prevention (CDC) and the National Nosocomial Infections Surveillance Network (NNISN) criteria (10,11). A total of 510 IDANIs were diagnosed over a five-year period. Invasive device-associated hospital infections rates;

Rate of VAP= Number of VAP /number of ventilator days in ICU x 1000

Rate of CVCR-BSI =Number of CVCR-BSI /number of central venous catheter days in ICU x 1000

Rate of CR-UTI =Number of CR-UTI / number of urinary catheter days x 1000

Rate of invasive device utilization=Number of device utilization days/number of disease days

Statistical Analysis

SPSS version 20.0 (IBM SPSS Statistics 20.0) was used for data evaluation and analysis. Variables are expressed as mean ± standard deviation, and categorical variables as numbers

RESULTS

HCAIs were detected in 1556 of the 34972 patients over the five-year period in ICUs. 510 of the HCAIs were IDANIs. The rates of invasive device utilization were 0.28 for mechanical ventilators, 0.39 for central venous catheters and 0.85 for urethral catheters. When IDANISs were evaluated among all healthcare-associated infections; the rates for ventilator-associated pneumonia (VAP) 2.7%, central venous catheter-related bloodstream infections (CVCR-BSI) 17.9%, catheter-related urinary tract infections (CR-UTI) 12%. When IDANIs were evaluated within themselves; CVCR-BSI 54.9%, CR-UTI 36.6%, VAP 8.4%. When compared according to years, there was a statistically significant decrease in CR-UTI, CVCR-BSI and VAP rates in 2020 ($p<0.05$) (**Table 1**).

Table 1. Distribution of invasive device-associated infection rates and utilization ratios according to years

VAP							
Years	**Number of patients**	**Number of days**	**Invasive device day**	**Number of infections**	**Device utilization ratio**	**The infection rates %**	**Incidence density**
2016	6131	24500	6106	12	0.25	1.97	0.49
2017	6205	26017	7077	7	0.27	0.98	0.26
2018	7101	30723	9415	9	0.31	0.95	0.29
2019	8454	34205	10364	12	0.30	1.15	0.35
2020	7081	38639	10223	3	0.26	0.29	0.07
Total	34972	154084	43185	43	0.28	0.99	0.28
CR-UTI							
Years	**Number of patients**	**Number of days**	**Invasive device day**	**Number of infections**	**Device utilization ratio**	**The infection rates %**	**Incidence density**
2016	6131	24500	19592	54	0.79	2.75	2.2
2017	6205	26017	20959	52	0.8	2.48	1,99
2018	7101	30723	25781	48	0.84	1.86	1.56
2019	8454	34205	29953	22	0.87	0.73	0.64
2020	7081	38639	35535	11	0.91	0.31	0.28
Total	34972	154084	131820	187	0.85	1.41	1.21
CVCR-BSI							
Years	**Number of patients**	**Number of days**	**Invasive device day**	**Number of infections**	**Device utilization ratio**	**The infection rates %**	**Incidence density**
2016	6131	24500	9618	61	0.39	6.3	2.48
2017	6205	26017	10055	71	0.38	7.06	2.72
2018	7101	30723	13546	59	0.44	4.35	1.92
2019	8454	34205	15111	58	0.44	3.83	1.69
2020	7081	38639	11813	31	0.3	2.62	0.8
Total	34972	154084	60143	280	0,39	4,6	1.81

Of these infections, *Klebsiella pneumoniae* was the most frequent pathogen. The distribution of factors causing invasive device-associated nosocomial infections is given in **Table 2**. When we look at the distribution of agents according to IDANIs, the most common agent detected in VAP is *Acinetobacter baumannii* with 61.1%, in CVCR-BSI is coagulase-negative staphylococcus (CNS) with 25.1%, in CR-UTI is *K. pneumoniae* with 28.7%.

Table 2. Agents and distributions of invasive device-associated nosocomial infections

Diagnoses of IDANIs	**Agents leading to IDANIs**	**n (%)**
VAP	*Acinetobacter baumannii*	41 (61.1)
	Klebsiella pneumoniae	13 (19.4)
	Pseudomonas aeruginosa	6 (8.9)
	Serratia marcescens	1 (1.6)
	Escherichia coli	1 (1.6)
	Staphylococcus aureus	2 (2.9)
	Stenetrophomonas maltophilia	2 (2.9)
	others	1 (1.6)
	Total	67 (100)
CVCR-BSI	*Acinetobacter baumannii*	51 (18)
	Klebsiella pneumoniae	48 (17)
	Pseudomonas aeruginosa	8 (2.8)
	Serratia marcescens	4 (1.4)
	Escherichia coli	4 (1.4)
	Enterobacter cloacae	4 (1.4)
	CNS	71 (25.1)
	Staphylococcus aureus	9 (3.1)
	Enterococcus faecalis	19 (6.7)
	Stenetrophomonas maltophilia	6 (2.1)
	Candida spp.	54 (19.1)
	others	4 (1.4)
	Total	282 (100)
CR-URI	*Acinetobacter baumannii*	16 (7.5)
	Klebsiella pneumoniae	61 (28.7)
	Pseudomonas aeruginosa	23 (10.8)
	Escherichia coli	41 (19.3)
	Enterobacter cloacae	4 (1.8)
	Enterococcus faecalis	54 (25.4)
	Staphylococcus aureus	2 (0.9)
	others	11 (5.1)
	Total	212 (100)

CNS: Coagulase negative staphylococcus, CR-URI: Catheter-related urinary tract infection, CVCR-BSI: Central venous catheter-related bloodstream infections, VAP: Ventilator-associated pneumonia

DISCUSSION

Considering the long-term hospitalization of high-risk patients in intensive care units, this situation causes invasive procedures to be applied more frequently. This increased the risk of infection development (12,13). Early diagnosis IDANIs and regular follow-up with active surveillance method the most important step in preventing HCAI.

In a study evaluating invasive device-associated nosocomial infections, while the rates of mechanical ventilator utilization and VAP were found to be 0.46 and 1.34 respectively, the rates of CVC use, CVCR-BSI, use of urinary catheter and CR-URI were detected as 0.72, 8.6, 0.99 and 3.45, respectively (14). In our study, while the rates of mechanical ventilator utilization and VAP were found to be 0.28 and 0.99, the rates of CVC use and CVCR-BSI were found to be 0.39 and 4.6, use of urinary catheter and CR-URI were detected as 0.85 and 1.4, respectively.

According to the National Nosocomial Infections Surveillance Network (NNISN) 2020 report, in the anesthesia and reanimation units in hospitals depending on the Ministry of Health around Turkey, the rates of mechanical ventilator utilization and VAP were found as 0.57 and 4 respectively (15). In our study, however, while the mechanical ventilator utilization rate was similar to NNISN 2020 report, the VAP rate was lower. The reason why our VAP rate was lower; the levels of ICUs in all hospitals may be different around Turkey, the patients' profile and bed capacity may also be different.

According to the NNISN 2020 report, in the anesthesia and reanimation units in hospitals depending on the Ministry of Health around Turkey, the rate of CVC utilization was 0.54; the rate of CVCR-BSI was 3.9. On the other hand, the rate of urinary catheter utilization was 0.97, and the rate of CR-URI was 1.1 (15). When we compared our findings with those stated in the NNISN report 2020, In our study, while the rates of CVC and urinary catheter utilization were lower, the rates of CVCR-BSI and CR-URI were similer. With these data, it can be said that regular inspections should be carried out in ICUs in our hospital and that the precautions to be taken while inserting the catheter are applied carefully. When we look only at the year 2020, the VAP rate was 0.29, the CVCR-BSI rate was 2.62, and the CR-UTI rate was 0.31, which was quite low compared to other years. This situation was associated with the use of masks, the use of protective equipment, and more hand washing due to the follow-up of COVID 19 patients in our hospital in 2020. İn the report of International Nosocomial Infection Control Consortium (INICC) device-associated module data of 45 countries from 2012-2015, DA-HAI rates were stated as 5.05 in CVCR-BSI, 14.1 in VAP and 5.1 in CR-UTI (16). In our study, only CVCR-BSI rates were same while other rates were lower. Common pathogens that are known to cause CR-UTI are *Enterococcus*, *S. aureus*, *Pseudomonas*, *proteus*, *Klebsiella*, and *Candida spp*. (17). According to the National Healthcare Safety Network, the common causative organisms for CVCR-BSI include *S. aureus*, CNS, *Enterococcus*, *E. coli*, *P. aeruginosa*, *Enterobacter*, *K. pneumoniae* (18). The most common pathogens for VAP are *S. aureus* and *P. aeruginosa* (19). In recent studies, although the frequency order of the agents has changed, the distribution of the main microorganisms was the same. Hence, in VAP the most common agent is *A. baumannii*. In our study, when we look at the distribution of agents according to IDANIs, the most common agent detected in VAP is *A. baumannii* (61.1%), *K. pneumoniae* (19.4%), *P. aeruginosa* (8.9%), in CVCR-BSI is CNS (25.1%), *Candida spp*. (19.1%) *A. baumannii* (18%), in CR-UTI is *K. pneumoniae* (28.7%), *E. faecalis* 25.4%, *E. coli* 19.3%. According to the NNISN 2020 report over the distribution of agents and antibiotic resistance, *Klebsiella spp*. (19.2%) was found to be the most common agent across Turkey (20). Our findings are consistent with those reported in other studies from Turkey. In the same report, in VAP; *Acinetobacter spp*. (43.3%), *Klebsiella spp*. (20.8%) *Pseudomonas spp*. (16.1%), in CVCR-BSI; *Acinetobacter spp*. (43.3%), *Klebsiella spp*. (20.8%), *Candida spp*. (17.6%), in CR-UTI; *Klebsiella spp*. (29.6%), *E. coli* (22.3%), *Pseudomonas spp*. (12.9%) were stated (20%). While the most common agents detected in VAP and CR-UTI were the similer in the same report, CVCR-BSI was different. However, in our study CNS was detected in the first place in CVCR-BSI (25.1%), in this report CNS was detected as 10.1 %.

CONCLUSIONS

Especially in intensive care units, the development of device-associated infections is inevitable, despite of more awareness and better guidelines. Active infection control programs that perform surveillance of infection and implement guidelines for prevention can improve patient safety and must become a priority in every hospitals. Best practices have now been established in most hospitals for the insertion of their procedures to prevent infections..

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was approved by local ethics committee, dated on 04th March 2021 and with the registration number of E-86737044-806.01.03.

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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