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Evaluation of nosocomial infections and risk factors in critically ill patients

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C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
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Summary

Background: Nosocomial infections are one of the most serious complications in intensive care unit patients because they lead to high morbidity, mortality, length of stay and cost. The aim of this study was to determine the nosocomial infections, risk factors, pathogens and the antimicrobial susceptibilities of them in intensive care unit of a university hospital.

Material/Methods: The patients were observed prospectively by the unit-directed active surveillance method based on patient and the laboratory.

Results: 20.1% of the patients developed a total of 40 intensive care unit-acquired infections for a total of 988 patient-days. The infection sites were the lower respiratory tract, urinary tract, bloodstream, wound, and the central nervous system. The respiratory deficiency, diabetes mellitus, usage of steroid and antibiotics were found as the risk factors. The most common pathogens were *Enterobacteriaceae, Staphylococcus aureus, Candida* species. No vancomycin resistance was determined in Gram positive bacteria. Imipenem and meropenem were found to be the most effective antibiotics to *Enterobacteriaceae.*

Conclusions: Hospital infection rate in intensive care unit is not very high. The diabetes mellitus, length of stay, usage of steroids, urinary catheter and central venous catheter were determined as the risk factors by the final logistic regression analysis. These data, which were collected from a newly established intensive care unit of a university hospital, are important in order to predict the infections and the antimicrobial resistance profile that will develop in the future.

key words: **intensive care unit • nosocomial infection • risk factors**

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Background

The intensive care units are treatment units that provide the vital support to the critically ill patients. Nosocomial infections (NIs) are one of the most serious complications in intensive care unit (ICU) patients because they lead to high morbidity, mortality, length of stay and cost [1]. Although only 5–10% of all hospitalized patients are treated in ICUs, they account for approximately 25% of all NIs [2]. Patients hospitalized in ICUs are 5 to 10 times more to acquire NIs than other hospital patients [3]. Patients admitted into ICUs are susceptible to infection because of their underlying diseases or invasive monitoring and they are disposed to the infections after exposure to broad-spectrum antimicrobials [2]. The high rate of nosocomial infection in ICU leads to use broad spectrum antibiotics and emergence of antibiotic resistant microorganisms. The mortality and treatment cost of the infection caused by the resistant strains is very high compared with the mortality and treatment cost infection caused by the susceptible strains [3]. On these grounds it is important to monitor and control of the NIs in ICUs.

The aim of this study was to determine the nosocomial infections, risk factors, causative agents and the antimicrobial susceptibilities of these agents in ICU of Mustafa Kemal University Hospital.

Material and Methods

This study was approved by Hospital Ethics Committee. All patients included in the study were admitted to the 10 bed mixed ICU for more than 48 hours during period of study from March 2007 to August 2007. The patients admitted to the ICU were observed prospectively by the unit-directed active surveillance method based on patient and the laboratory. Patients who stayed in ICU less than two days were excluded. They were prospectively followed up including five days after discharge from ICU. Infections that developed 48 hours after admission into the ICU were considered ICU acquired. The presence and criteria of infection were assessed daily on the ward round together with an infectious disease specialist. Urine bacterial culture was routinely performed on admission. Microbiological samples of blood, urine, tracheobronchial secretions, and any suspected infection focus were always obtained when a new infection was suspected. The definitions of infections were based on the definitions proposed by the Centers for Disease Control and Prevention. The risk factors were selected in the light of a review summarizing previously published articles about nosocomial infections in ICUs [2]. The following information was collected for all study patients: age, gender, cause of admission, severity of underlying diseases and organ dysfunction on admission as assessed by means of the Acute Physiology and Chronic Health Evaluation (APACHE) II, presence of ischemic heart disease, chronic obstructive pulmonary disease, diabetes mellitus, chronic renal or hepatic failure, intoxication, foreign body and prosthesis, underlying malignancy, general body trauma, recent use of immunosuppressive therapy, elective or emergency operations, previous antimicrobial therapy, prior hospitalization, parenteral nutrition, transfusion.

Susceptibility testing of microorganisms was done according to recommended Clinical and Laboratory Standards Institute (CLSI) guidelines [4]. The automated Vitek bacteriology system (bioMerieux Vitek, France) was used for the identification of microorganisms and susceptibility testing.

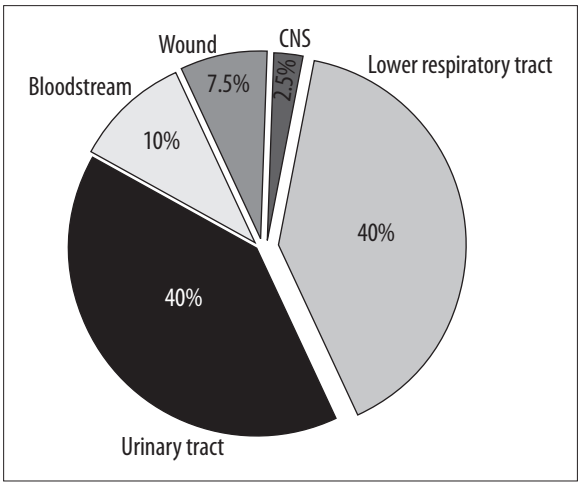

Figure 1. The infection sites.

Statistical analysis

Student's t test, Mann-Whitney U test, χ^2 and Fisher's exact χ^2 tests were used for statistical analysis. $P \leq 0.05$ was considered significant. Also a logistic regression model was used in order to evaluate the risk factors of infections.

Results

A total of 250 patients were admitted during this 6-month period. 149 patients (61 female and 88 male) with a mean age of 61.1±18.1 (min 15 – max 94) were involved in this study. They stayed a mean of 6.6±5.9 (min 2– max 30) days in ICU. A mean of APACHE II scores was found as 13.2±4.8 (min 4 – max 26).

20.1% (n=30) of the patients developed a total of 40 ICU-acquired infections for a total of 988 patient-days. Nosocomial infection was diagnosed at a mean of 5.4±4.9 (min 2 – max 23) days after the admission in ICU. One event of NI occurred in 23 patients (76.7%), 5 (16.7%) had 2 infections and 2 (6.7%) had 3 or more. The infection sites were the lower respiratory tract (40%), urinary tract (40%), bloodstream (10%), wound (7.5%), and the central nervous system (CNS) infection (2.5%). The sites of infection are summarized in Figure 1.

A total of 52 patients had ischemic heart disease, 32 (21.5%) had undergone surgery before admission whom 23 (15.4%) emergency, 9 (6%) had elective surgery, 29 (19.5%) had cerebrovascular disease, 19 (12.8%) had diabetes mellitus and 13 (8.7%) chronic obstructive pulmonary disease, 13 (8.7%) had gastrointestinal hemorrhage.

116 patients (77.9%) had a urinary catheter, 37 (24.8%) had a nasogastric tube, 28 (18.8%) were being mechanically ventilated, 25 (16.8%) were being intubated, 8 (5.4%) had a tracheostomy, 7 (4.7%) had an arterial catheter, 6 (4%) had a central venous catheter, 6 (4%) had drenage catheter.

Table 1. Characteristics of the patients and risk factors for nosocomial infections.

Characteristics		Patients with NI (n)	Non-infected patients (n)	*P* value
Gender	Female	11	50	>0.05
	Male	19	69	
Age (mean)		61.1±17.9	61.1±18.3	>0.05
APACHE II score on admision (mean)		13.9±4.7	12.9±4.5	>0.05
Length of stay (mean)		12.8±8.6 days	5.1±3.8 days	<0.05
Length of stay	≥6 days	9	88	<0.05
	<6 days	21	31	
Mortality		16	28	<0.05
Underlying disease				
General body trauma		3	9	>0.05
Malignancy		2	15	>0.05
Diabetes mellitus		8	11	<0.05
Neutropenia		1	4	>0.05
Renal failure		1	2	>0.05
Liver failure		1	5	>0.05
Cerebrovascular disease		10	19	>0.05
Cardiovascular disease		8	44	>0.05
Chronic obstructive lung disease		1	12	>0.05
Admission diagnosis				
Unconsciousness		10	41	<0.05
Respiratory deficiency		12	27	<0.05
Postoperative		7	15	>0.05
Cardiopulmoner arrest		2	8	>0.05
Intoxication		1	4	>0.05
Aspiration pneumonia		1	1	>0.05
Emergency surgery		7	16	>0.05
Elective surgery		–	9	>0.05
Other risk factors				
Usage of H_2 receptor blocker		26	96	>0.05
Usage of steroid		15	19	<0.05
Usage of immunosuppressive drug		6	10	>0.05
History of hospitalization		4	18	>0.05
Transfusion		4	9	>0.05
Parenteral nutrition		18	16	>0.05
Urinary catheter		25	91	>0.05
Central venous catheter		4	3	<0.05

The respiratory deficiency, diabetes mellitus, usage of steroid and antibiotics were found as the risk factors for nosocomial infection. And male sex, respiratory deficiency, unconsciousness, intubation, mechanical ventilation and colonization of organisms in the lower respiratory tract were found as the main risk factors for lower respiratory tract infection. Only usage of antibiotic was found to be the risk factor for urinary tract infection. Analysis (Table 1) of the clinical characteristics of patients with and without NI denoted that numerous factors were associated with the occurrence of infection.

Final logistic regression analysis showed that diabetes mellitus, length of stay, usage of steroid, urinary catheter and central venous catheter were statistically significant risk factors for nosocomial infection in ICU (Table 2).

Table 2. Risk factors for nosocomial infections after logistic regression analysis.

Risk Factor	Odds Ratio	95% CI	P value
Diabetes mellitus	0.150	0.034–0.655	0.012
Length of stay	0.199	0.054–0.737	0.016
Usage of steroid	0.252	0.072–0.883	0.031
Urinary cathater	5.054	0.977–26.142	0.053
Central venous catheter	0.010	0.01–0.210	0.003

Table 3. The clinical materials from which the pathogens were isolated.

	Tracheal asp.	Sputum	Urine	Blood	Wound	Cerebrospinal fluid	Total
Enterobacteriaceae	4	1	5	1	2	–	12
Staphylococcus aureus	7	–	1	1	1	–	10
Candida spp.	–	–	7	1	–	1	9
Pseudomonas aeruginosa	5	–	–	–	–	–	5
Enterococcus spp.	2	–	2	1	–	–	5
Acinetobacter spp.	3	–	1	–	–	–	4
Total	21	1	16	4	3	1	46

Among the total patients, 44 (29.5%) died and 16 (36.4%) was detected with and 28 (63.6%) without NI. The difference in mortality rate between presence of NI and absence of NI groups was significant.

The Table 3 summarizes the organisms isolated from the nosocomial infections. The most common pathogens found were as follows: *Enterobacteriaceae* (26.1%), *Staphylococcus aureus* (21.7%), *Candida* species (16.7%), *Pseudomonas aeruginosa* (10.9%), *Enterococcus* species (10.9%), and *Acinetobacter* species (8.7%).

It was found to have the highest antimicrobial resistance, with 8/10 resistant to methicillin, sulbactam-ampicillin, cefazolin, erytromycin, gentamicin, ciprofloxacin, ofloxacin in the strains of *S. aureus.* Trimethoprim/sulphamethoxazole, clindamycin, teicoplanin and vancomycin were found to be the most effective antibiotics to *S. aureus.* Of all the *Enterococcus* isolates recovered from patients in the ICU, 5/5 of the *Enterococ* strains were penicillin and ciprofloxacin resistant and 4/5 of them resistant to tetracycline. No vancomycin resistance was determined in Gram positive bacteria. Imipenem and meropenem were found to be the most effective antibiotics to *Enterobacteriaceae.* It was found to have the highest antimicrobial resistance, with 9/12 resistant to ampicillin and amoxicillin clavulanic acid. Within the *P. aeruginosa* strains there was no resistance to amikacin. But ceftazidime, gentamicin, mezlocillin, piperacillin/tazobactam were found to have the highest antimicrobial resistance within *P. aeruginosa* strains.

The most frequently prescribed antibiotics were third generation cephalosporins (32.9%), quinolones (17.4%), metronidazole (15.4%), first generation cephalosporins (8.7%), and aminoglycozides (8.7%).

Discussion

The nosocomial infection rates vary according to the geographical location, type of ICU, patient population and local infection control practices [5,6]. More than one third of NIs is acquired in ICUs, the incidence of 15 to 40% of hospital admissions, depending on the type of unit [2]. Such infections prolong the length of ICU stay and bring an important economic difficulty [7].

We performed this study, intending to evaluate the development of nosocomial infections, sites of infections and the most prevalent microorganisms and the antimicrobial resistance patterns in the ICU of a university hospital.

There were 250 admissions to the ICU during the study. 149 patients were involved in the study. The results of our study demonstrated a similar NI rate with other ICUs. It was 20.1%, similar to that observed by Klavs et al. [8]. Also in our study it was determined lower NI rates than that in many university hospitals in Turkey [10–12] and in the other countries [6,7]. In other countries and in our country nosocomial infection rates in ICUs were reported between 23.2% and 30.6%; this rate is similar to our study [13–15].

NIs acquired frequently in ICU is lower respiratory tract, urinary tract, bloodstream, surgical wound and catheter associated infections [2]. In our study we found the lower respiratory tract and urinary tract to be the most frequent nosocomial infection. Other infection sites were bloodstream, wound, and the CNS infection respectively. Although the infection sites are in contrast to some studies, this is also same with some studies reported from the other countries [13,14–16]. The rate and sites of NIs can vary between countries according to the establishment of preventive measures and developmental status, between the hospitals according to the spectrum of their patients, between the wards of the hospitals according to treatment and intervention.

It is important to know and control the risk factors for nosocomial infection. The risk factors for NIs in ICU were investigated in internal and overseas studies. In this study the finding of a relationship between diabetes mellitus, usage of steroid, antibiotics and nosocomial infection was in accordance with the literature (17). The finding of a relationship between respiratory deficiency, unconsciousness, intubation, mechanical ventilation and lower respiratory tract infection were found in accordance with the literature [18,19].

Urinary catheterization was recognized as the main risk factor for nosocomial infection by Girou et al. [20] and mechanical ventilation was recognized as the main risk factor for nosocomial pneumonia by McCusker et al. [21] and Gusmào et al. [19] in previous studies. Leone et al. [22]. reported that female sex, length of ICU stay and duration of catheterization were associated with an increased risk of urinary tract infection. Apostolopoulou et al. [23] reported that duration of mechanical ventilation ⩾5 days was risk factor for ventilator

associated pneumonia. Meric et al. [24] reported into a study from our country, a length of stay in ICU (>7 days), respiratory failure as a primary cause of admission, sedative medication and operation (before or after admission to ICU) as significant risk factors for NIs in ICU.

Girou et al. [20] reported that nosocomial infection rates were significantly higher in those who had equal or a higher than 21 APACHE II score, and Apostolopoulou et al. [23] reported the equal or a higher than 18 APACHE II score as a risk factor for nosocomial infections. We did not find significant relation between APACHE II score and NI contrary with Girou et al. [20] and Apostolopoulou et al. [23].

The spectrum of potential pathogens and the predominant bacterial flora can vary considerably in different ICU settings. In this study *Enterobacteriaceae* was found the most common pathogens. *S. aureus* and *P. aeruginosa* were the predominant pathogens in lower respiratory tract infections. *Candida* spp. and *E. coli* were the predominant pathogens in urinary tract infections. In the surveillance studies from European countries, *S. aureus* and coagulase negative staphylococ among the gram positive bacteria and *P.aeruginosa* and *E.coli* among the gram negative bacteria were reported to be isolated [25,26]. *Candida* species are causative agents of urinary tract infections of the patients who are under consistent antibiotic treatment and have urinary catheter [22]. There are studies which reported fifth *Candida* species or less than fifth [8]. In our study *Candida* species were isolated with third frequency. In our study one *Candida* spp. was determined to be caused by meningitidis. In a normally way *Candida* spp. is not isolated from the CNS infections. In this study it was isolated from the patient who had a shunt.

In the multicenter studies, high resistance rates were determined. But there was a great difference between the centers [25,26]. For this reason every hospital needs to determine their own resistance patterns.

The antimicrobial resistance rates of the microorganisms isolated in nosocomial infections are higher than that isolated from the outpatients and the percentage of resistant isolates from the patients in ICU is also higher than that from outpatients or the other wards [27,28].

Concerning resistance pattern for *S. aureus*, 8/10 were resistant to methicillin and all of them had susceptible to vancomycin. Among the strains of *Acinetobacter* none revealed sensitivity higher than 2/4 to any antimicrobial tested. Amikacin was found to be the most effective antibiotic to the strains of *P. aeruginosa*. These data confirm that the organisms develop maximum resistance against the antibiotics which are most frequently prescribed.

Conclusions

In this study hospital infection rate in ICU is not very high, being similar to rates previously reported from other units of our country. The respiratory deficiency, diabetes mellitus, usage of steroid and antibiotics were found as the risk factors for nosocomial infection. And male sex, respiratory deficiency, unconsciousness, intubation, mechanical ventilation and colonization of organisms in lower respiratory tract were found as the main risk factors for lower respiratory tract infection. Only usage of antibiotic was found to be the risk factor for urinary tract infection. The diabetes mellitus, length of stay, usage of steroid, urinary cathater and central venous catheter were determined as the risk factors for nosocomial infection in ICU by the final logistic regresion analysis. These data, which were collected from a newly established ICU of a university hospital, are important in order to predict the infections and the antimicrobial resistance profile that will develop in the future.

Conflict of interest

There are no conflicts of interest.

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