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Research Article

Risk factors and Incidence of Catheter-Related Bloodstream Infections in a Tertiary Hospital ICU

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Abstract

Objectives: Catheter-related bloodstream infections (CRBSI) are a major cause of morbidity and mortality in intensive care unit (ICU) patients. The objective of this study was to assess the risk factors and incidence of catheter-related bloodstream infections in our hospital ICU.

Methods: Over twelve months, a prospective observational study was performed in a 27-bed anesthesia-resuscitation and ICU, located in a 1000-bed education research hospital at Turkey. CRBSIs were recorded and analyzed.

Results: Three-hundred seventeen patients were evaluated, and a total of 433 central venous catheters (CVCs) were inserted for a duration >48 h. Patients' median age was 66 (IQRs=56-77), and 56.8% were male. The incidence of CRBSI was 8.2 per 1000 catheter days. No significant relationship was found between several parameters: 1) age; 2) gender; 3) comorbid conditions; 4) catheter insertion site; and 5) main reason for ICU admission ($p>0.05$). Risk factors independently associated with CRBSI were diabetes mellitus, long duration of catheterization, length of stay ICU and parenteral nutrition. The most common pathogens were Methicillin-resistant coagulase-negative *staphylococci* and *Candida albicans*.

Conclusion: In our study, it was concluded that the duration of catheterization and the time of parenteral nutrition treatment should be as short as possible. In addition, an association between CRBSIs and prolonged ICU stay and mortality was observed.

Keywords: Bacteremia, catheter-related infections, cross infection, equipment contamination

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Central venous catheters (CVCs) are used for the purpose of applying medication, performing hemodialysis, and hemodynamic monitoring in cases such as pneumothorax, hematoma, and vascular injuries. These conditions can cause mechanical complications in addition to the development of infections. Regular and frequent CVC use in intensive care units (ICUs) can lead to bloodstream infections termed catheter-related bloodstream infections (CRBSI).[1, 2]

Catheter-related bloodstream infections are a major cause of poor patient prognosis and mortality. CRBSIs significantly affect the length of hospital stays and quality of a patients' lives. The most common causes of CRBSIs are contamination of the catheter hub and entry of skin flora into the patient's bloodstream during/after CVC insertion.[3, 4]

The median rate of CRBSI in intensive care units (ICU) in the United States varies from 1.8 to 5.2 per 1000 catheter days. In Turkey, the median rate of CRBSI in ICUs ranges from 1.3 to 6.6 per 1000 catheter days.[5, 6]

The aim of this study was to provide an overview of CRBSI rates, causative pathogens and associated risk factors.

Methods

Patients and Data Collection

Over twelve months (1 July 2014-1 July 2015) a prospective, observational study was performed in a 27-bed anesthesia-

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resuscitation ICU located in a 1000-bed education research hospital in Turkey. Local Ethics Committee approval was obtained (19.06.2013; no. 1; session. 51). The informed consent was obtained from conscious patients, and consent was obtained from relatives of unconscious patients.

Demographic information, administrative information, vital signs, and laboratory data including follow-up forms are filled out for all CVC-inserted patients. They were monitored daily for the development of CRBSI during the study period. If a patient has more than one CVC inserted during the ICU stay, each CVC that was inserted that was enrolled as a separate study sample. Patients who presented with a catheter(s) that were inserted in other hospitals or ICUs and those in whom CRBSI was diagnosed within the first 48 h were excluded from study.

Data collected from the medical charts of the patients and from the treating physicians included gender, age, reason(s) for hospitalization, CVC insertion site, CVC insertion situation (emergency or elective), total duration of catheterization, use of total parenteral nutrition (TPN), total length of hospitalization, pathgenic species identification and its (their) antimicrobial susceptibility, and final outcome. In addition, comorbid conditions were also documented.

Microbiological Procedures

Specimens to be used for microbiological cultures were obtained from all patients from several sites: 1) the distal 4-5 cm of the tip after CVC removal; 2) two blood samples, drawn from the catheter and a peripheral vein; or 3) if a blood sample cannot be drawn from a peripheral vein, two blood samples were drawn through different catheter lumens.

The definitions of CRBSI published by the Infectious Diseases Society of America were used[7] as follows:[4]

"Bacteremia or fungemia in a patient who has an intravascular device and >1 positive blood culture result obtained from the peripheral vein, clinical manifestations of infection (e.g., fever, chills, and/or hypotension), and no apparent source for bloodstream infection (with the exception of the catheter)."

One of the following should be present: a positive result of semiquantitative (>15 cfu per catheter segment) or quantitative (>102 cfu per catheter segment) catheter culture, whereby the same organism (species) is isolated from a catheter segment and a peripheral blood culture; simultaneous quantitative cultures of blood with a ratio of >3:1 cfu/mL of blood (catheter vs. Peripheral blood); differential time to positivity (growth in a culture of blood obtained through a catheter hub is detected by an automated blood culture system at least 2 h earlier than a culture of simultaneously drawn peripheral blood of equal volume).

Laboratory Procedures

Blood cultures were processed using the automated blood culture system (BacT/Alert, bioMérieux, France). The growth of ≥15 colonies in the semi-quantitative method and ≥103 cfu/mL in the quantitative method were considered positive blood cultures. All positive catheter and blood cultures were further managed according to standard microbiological procedures. Identification and antimicrobial susceptibility testing of microbial isolates were performed with the automated identification system (VITEK® 2, bioMérieux, France). Isolates showing intermediate susceptibility were considered resistant. The blood cultures that were taken from inside the catheter and from the peripheral vascular system were evaluated according to whether the same type of microorganism and antibiotic susceptibility was present. Antibiotic susceptibility testing, depending on species identification, was performed using the disk-agar diffusion method according to the European Union Committee on Antimicrobial Susceptibility Testing (EUCAST).

Statistical Analysis

For data analysis, the statistical software Statistical Package for the Social Sciences (IBM SPSS Statistics Armonk, NY, USA) version 21 was used. Categorical variables were defined as the number of observations and percentages, while continuous variables were expressed as median and interquartile ranges (IQRs). The normality assumption of continuous variables was evaluated using the Kolmogorove Smirnov criterion. The categorical variables were compared with the chi-square test. For variables that are incompetent with normal distribution, the non-parametric Mann Whitney-U test was used for two-group comparisons, and for more than two-group comparisons, the Kruksal Wallis test was used. Odds ratios and 95% confidence intervals were computed from the results of logistic regression analysis. Values of $p<0.05$ were considered statistically significant.

Results

Among 317 patients admitted in the ICU during the study period, a total of 433 CVCs were inserted for a duration >48 h and the total catheterization duration was 4893 days. During the study period, a total of 326 patients were included in the study; nine patients were excluded because their data were incomplete. As a result, 317 patients were evaluated in this study.

Patients' median age was 66 (IQRs=56-77). One hundred eighty patients (56.8%) were male, and 137 (43.2%) were female.

Overall, 40 (12.6%) patients were classified as having CRBSI. CRBSI incidence was 8.2 per 1000 catheter days. The median duration of catheterization was seven days (IQRs=3-

15) and length of stay in ICU was eight days (IQRs=3-18.5). CVC insertion sites included the internal jugular (42.6%), subclavian (41.6%), and femoral veins (15.8%). Incidences of CRBSI in CVC insertion sites were 11.5 (internal jugular), 7.3 (subclavian) and 6.5 (femoral veins) per 1000 catheter days.

The main reason for ICU admission and patient characteristics are given in Table 1. The most common comorbid conditions were chronic kidney disease (18.3%), diabetes mellitus (14.8), and solid organ neoplasm (12.9%). The crude mortality rate among ICU patients was 56.2% (n=178). And the mortality rate was higher in patients with CRBSI (p=0.01).

Table 1. The patient characteristics and analysis of data

Variable	Patient groups		p
	With CRBSI n (%)	Without CRBSI n (%)	
Age (median (IQRs) years)	59 IQRs (55-71.2)	67 IQRs (56-78)	0.330
Gender			
Female	17 (5.4)	120 (37.9)	0.922
Male	23 (7.3)	157 (49.5)	
Main reason for ICU admission			
Septic Shock	1 (0.3)	28 (8.8)	0.066
Cardiac problems	3 (0.9)	6 (1.9)	
Malignant tumor	3 (0.9)	40 (12.6)	
Pnuemonia	2 (0.6)	13 (4.3)	
COPD	1 (0.3)	2 (0.6)	
Gastrointestinal bleeding	2 (0.6)	7 (2.2)	
Trauma	6 (1.9)	35 (11)	
Acute Renal Failure	3 (0.9)	29 (9.1)	
Surgery	8 (2.5)	78 (24.6)	
Central nervous system	8 (1.8)	25 (7.9)	
Pulmonary embolism	0 (0)	5 (1.6)	
Hepatopancreatobiliary	0 (0)	4 (1.3)	
Intoxication	3 (0.9)	5 (1.6)	
Comorbidities			
None	26 (8.2)	141 (44.8)	0.129
Diabetes mellitus	1 (0.3)	46 (14.5)	
Solid tumor	5 (1.6)	36 (11.4)	
Hematological malignancy	1 (0.3)	2 (0.6)	
Chronic kidney disease	7 (2.2)	51 (16.1)	
Clinical outcome			
Exitus	30 (75)	148 (53.4)	0.010
Survive	10 (25)	129 (46.6)	
Diabetes mellitus			
Yes	1 (2.5)	46 (16.6)	0.019
No	39 (97.5)	231 (83.4)	
Surgery			
Yes	8 (20)	78 (28.2)	0.278
No	32 (80)	199 (71.8)	
Length of stay ICU	19.5 IQRs (10.5-35)	7 IQRs (3-15.5)	<0.001
Duration of catheterization	15.5 IQRs (7-26.8)	6 IQRs (2-13)	<0.001
Catheter site			
Femoral	9 (19.1)	96 (24.9)	0.677
Internal jugular	18 (38.3)	133 (34.5)	
Subclavian	20 (42.6)	157 (40.7)	
Parenteral nutrition			
Yes	41 (87.2)	276 (71.5)	0.021
No	6 (12.8)	110 (28.5)	
Insertion context			
Emergency	6 (12.8)	35 (9.1)	0.414
Programmed	41 (87.2)	351 (90.9)	

CRBSI: Catheter-related bloodstream infection; COPD: Chronic obstructive pulmonary disease; IQR: Interquartile range; ICU: Intensive care unit.

There were no significant differences in terms of age, gender, comorbid conditions, catheter insertion sites, and main reasons for ICU admission vs the presence of CRBSI (p values were 0.330, 0.922, 0.066, 0.414, and 0.129, respectively; Table 1). There was a significant difference in term of length of stay ICU and duration of catheterization between presence of CRBSI (p values were <0.001). Patients who received parenteral nutrition treatment had higher rates of CRBSI (p=0.021) (Table 1).

The logistic regression analysis was used to identify independent risk factors for CRBSI (Table 2). Patients who had diabetes mellitus were almost 12 times more likely to develop a CRBSI (OR=11.96; 95% CI, 1.39-102.4; p=0.024).

The most common pathogens were Methicillin-resistant coagulase-negative *staphylococci* (MR-CoNS) (24.5%), *Candida albicans* (18.4%), *Acinetobacter baumanii* (12.2%) and *Pseudomonas aeruginosa* (12.2%). Pathogens isolated from patients with CRBSI are shown in Table 3.

Discussion

In our study, the incidence of CRBSI was high. Risk factors independently associated with CRBSI were diabetes mellitus, long duration of catheterization, length of stay ICU and parenteral nutrition. The mortality rate was higher in patient with CRBSI. The most common pathogens were MR-CoNS and *C. albicans*. No significant relationship was found between following parameters; age, gender, comorbid condition, catheter insertion site and main reason for ICU admission.

Compared with the US and Turkey surveillance reports, the rate of CRBSI in our study was substantially higher.[5, 6] In our study, the main causes of this result were long duration of catheterization, length of stay ICU and parenteral nutrition. And, it is well known that the bundle approach for the central catheters significantly reduces line-associated bloodstream infections.[8] We have planned to implement a bundle and training program to effectively reduce infection rates in our hospital.

CRBSIs are independently associated with increased hospital stays and costs but have not generally been shown to independently increase mortality.[2–5] In our study, the mortality rate was higher in patients with CRBSI and our crude mortality rate among ICU patients was higher at the same time. Therefore, the hospital management should take measures to reduce catheter infections as low as possible.

Risk factors for development of CRBSI include the duration of catheterization, the presence of parenteral nutrition treatment, and the emergent placement of catheter.[1, 10–12] In our study, our results supported this conclusion; patients who had longer CVC duration and received parenteral nutrition had a higher CRBSI rate. But no differences were found between programmed and emergency catheter insertion. Nevertheless, the placement of CVCs under emergency conditions increased infective complications be-

Table 3. Pathogen microorganisms

Pathogens	n	%
MR-CoNS *	12	24.5
Candida albicans	9	18.4
Acinetobacter baumanii	6	12.2
Pseudomonas aeruginosa	6	12.2
Enterococcus faecalis	4	8.2
Klebsiella pneumoniae	4	8.2
Escherichia coli	3	6.1
Proteus mirabilis	2	4.1
Enterococcus faeceum	1	2.0
Enterobacter aerogenes	1	2.0
Serrasia marcescens	1	2.0
Total	49	100

*MR-CoNS: Methicillin-resistant coagulase-negative *staphylococci*.

Table 2. The risk factors associated with CRBSI (multivariate analysis)

Variable	Patient groups		p	OR (95% CI)
	With CRBSI n	Without CRBSI n		
Diabetes mellitus				
Yes	1	46	0.024	11.96 (1.39-102.4)
No	39	231		
Length of stay ICU	19.5 IQRs (10.5-35)	7 IQRs (3-15.5)	0.147	0.99 (0.98-1.00)
Duration of catheterization	15.5 IQRs (7-26.8)	6 IQRs(2-13)	0.033	0.97 (0.95-0.99)
Parenteral nutrition				
Yes	41	276	0.024	0.33(0.13-0.86)
No	6	110		

CRBSI: Catheter-related bloodstream infection; IQR: Interquartile range; ICU: Intensive care unit; OR: Odds ratio (95% confidence interval).

cause of noncompliance to insertion protocols. Therefore, the catheters should be removed immediately when the patients become stable.[13]

Microorganisms that cause catheter infections often come from either the tip of the catheter or from the skin around the catheter.[14] The most common pathogens are Coagulase-negative *staphylococci*, *Staphylococcus aureus*, aerobic gram-negative bacilli and *C. albicans*.[15] In our study the most common microorganisms in order were MR-CoNS, *C. albicans*, and *Acinetobacter baumanii*. *C. albicans* was the second most common microorganism in this study, and it may be associated with prolonged parenteral nutrition in patients with CRBSI. *Acinetobacter baumanii* was also the most common pathogen in our hospitals' ICUs.

Limitation

There were limitations in our study. First, our study was done observationally. Secondly, our study was a single-center study in one hospital in Turkey. So the generalization of the results may not be appropriate.

Conclusion

In our study, it was concluded that the duration of catheterization and the time of parenteral nutrition treatment should be as short as possible. In addition, an association between CRBSIs and prolonged ICU stay and mortality was observed.

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Disclosures

Ethics Committee Approval: The study was approved by the Local Ethics Committee.

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Conflict of Interest: None declared.

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