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Original Communications

Risk Factors of Catheter-Related Bloodstream Infections in Parenteral Nutrition Catheterization

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ABSTRACT. *Background:* Intravascular catheters are integral to the practice of modern medicine. Potential risk factors for catheter-related bloodstream infection (CRBSI) include underlying disease, method of catheter insertion, and duration and purpose of catheterization. The administration of parenteral nutrition (PN) through intravascular catheters increases CRBSI risks. The purpose of this study was to evaluate the risk factors of CRBSI in patients with PN administration. *Methods:* This study was conducted at the Karadeniz Technical University Hospital between October 2003 and November 2004. All the patients to whom PN was administered through intravascular catheters were prospectively monitored for the presence of CRBSI and risk factors. *Results:* During the study period, 111 intravascular catheters through which PN was administered were monitored for a total of 1646 catheter-days. CRBSI was determined in 31 cases, a CRBSI rate of 18.8 per 1000 catheter-days. When risk factors affecting CRBSI were investigated using logistic regression, an increase in APACHE II score (OR, 1.10; 95% CI, 1.01–1.21; $p = .012$), prolongation of catheterization (OR, 1.08; 95% CI, 1.02–1.14; $p = .004$), catheterization in emergent conditions (OR, 5.45; 95% CI, 1.20–24.82; $p = .016$), and poor patient hygiene (OR, 4.38; 95% CI, 1.39–13.78; $p = .019$) were all determined to be independent risk factors. Proper implementation of hand hygiene and maximal barrier precautions during the insertion of catheters reduced CRBSI levels (OR, 0.28; 95% CI, 0.09–0.88; $p = .003$ and OR, 0.26; 95% CI, 0.08–0.93; $p = .017$, respectively). *Conclusions:* It was concluded that the duration of catheterization should be shortened; that the intravascular catheter, which is inserted in urgent situations, should be removed as soon as possible; and that maximal sterile barrier precautions should be taken and due attention should be paid to hand hygiene. (*Journal of Parenteral and Enteral Nutrition* **31:**284–287, 2007)

Intravascular catheters are integral to the practice of modern medicine. The use of these catheters is often complicated by mechanical or infectious complications, which may result in patient morbidity or premature catheter removal. Infection is a serious complication of intravascular catheters.[1,2] An intravascular catheter-related bloodstream infection (CRBSI) rate of 0.33 to 20.06 per 1000 catheter-days has been reported in the literature.[3–8] The use of central venous catheters (CVCs) for the administration of parenteral nutrition (PN) is a risk factor for CRBSI.[1,2,5,9–11] Potential risk factors for CRBSI include underlying disease, poor patient and personnel hygiene, the experience of the person inserting the catheter, the method and site of catheter insertion, duration of catheterization, and cumulative number of catheter manipulations.[1,2,5,7–13]

The purpose of this study was to evaluate the incidence and risk factors of CRBSI in patients with PN administration.

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MATERIALS AND METHODS

The study was conducted at the Karadeniz Technical University Hospital between October 2003 and November 2004. All patients to whom PN was administered through CVCs were prospectively monitored for the presence of CRBSI and risk factors. The incidence and risk factors of CRBSI in patients with administration of PN were evaluated by comparing the CRBSI group and others (control group).

CVCs used for the administration of PN were monitored for the duration of their insertion, and data were obtained daily regarding inflammation of the catheter sites and surveyed for bloodstream infections by an infection control team. The following data were prospectively collected by the infection control team and nurses in charge of clinics: age, sex, underlying disease, Acute Physiology and Chronic Health Evaluation (APACHE) II score, dates of hospital admission and discharge, date and site of catheter insertion, use of maximal sterile barriers for insertion and maintenance, patient hygiene, duration of catheterization, number of catheter manipulations, administration of antibiotics at the time of catheterization, occurrence of complications, and date of removal of the catheter. Observation of hand hygiene was performed by the infection control team before palpating catheter inser-

TABLE I
Risk factors for CRBSI in patients with CVCs used for the administration of PN (univariate analysis)

Risk factors	CRBSI, n = 31 (%)	Control group, n = 80 (%)	*p*	OR	95% CI
Age	49.7 ± 20.7	52.5 ± 20.6	.521		
Sex (male/female)	18/13	50/30	.666	0.83	0.33–2.10
APACHE II	16.8 ± 6.9	13.1 ± 6.4	.012		
Number of risk factors	9.9 ± 2.1	7.8 ± 2.2	<.0001		
Underlying disease					
Malignancy	3	9	.556	0.85	0.17–3.78
Diabetes mellitus	4	5	.216	2.22	0.46–10.54
Surgical intervention	15	32	.422	1.41	0.56–3.52
Antimicrobial usage	22	55	.998	1.11	0.41–3.04
Steroid usage	12	27	.623	1.24	0.48–3.18
Duration of catheterization	18.9 ± 11.5	13.2 ± 8.2	.004		
Catheter location					
V. subclavia	23	58	.953	1.09	0.39–3.12
V. jugularis	1	2	1.000		
V. femoralis	7	20	.984	0.88	0.29–2.59
Multi-lumen catheter	19	54	.538	0.76	0.30–1.97
Emergency situation at catheter insertion	9	8	.016	3.68	1.13–12.15
Catheterization by inexperienced personnel	25	54	.255	2.01	0.67–6.24
High number of catheter manipulations	22	46	.191	1.81	0.68–4.87
Hand hygiene	7	50	.0003	0.17	0.06–0.49
Maximal sterile barrier precautions	12	51	.017	0.36	0.14–0.91
Poor patient hygiene	18	27	.019	2.72	1.07–6.96

APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; CRBSI, catheter-related bloodstream infection; CVC, central venous catheter; OR, odds ratio risk; PN, parenteral nutrition.

tion sites, as well as before and after inserting, replacing, accessing, repairing, or dressing CVCs. Assessed during the catheterization by the infection control team, patient hygiene status (good or poor) was determined subjectively. "Emergency situation at catheter insertion" is the insertion of CVC into the patient either in the emergency unit or in clinically urgent situations. "Catheterization by inexperienced personnel" means that the CVC insertion process is carried out by inexperienced doctors.

After aseptic catheter removal, a 4-cm segment from the tip section of each catheter was cultured using the sonication technique.[14] Cultures yielding 10^3 colony forming units (cfu) or more colonies were recorded as positive. Blood samples of 3–7 mL from catheter and peripheral veins were cultured. Differential times to positivity were used between catheter and peripheral vein blood culture. Skin and hub specimens were cultured using the semiquantitative method. Cultures yielding 15 or more colonies were recorded as positive. All cultures were inoculated within 2 h of catheter removal. Standard laboratory methods were used to identify microorganisms.[15]

CRBSI was defined according to Centers for Disease Control and Prevention (CDC) criteria.[1]

Statistical Analysis

The χ^2 or Fisher's test was used to determine significant differences between categorical variables. Continuous variables were analyzed using Student's *t*-test or the Mann-Whitney *U* test. A *p* value <.05 was considered significant. Variables determined to be significant at univariate analysis were taken into logistic regression. The software package used for statistical analysis was SPSS for Windows, release 10.0 (SPSS Inc, Chicago, IL).

RESULTS

A total of 111 CVCs through which PN was administered were monitored for a total of 1646 catheter-days. CRBSI was determined in 31 cases, a CRBSI rate of 18.8 per 1000 catheter-days.

Univariate analysis revealed that a high APACHE II score, the cumulative number of risk factors, duration of catheterization, an emergency situation applying at catheter insertion, a failure to use maximal barrier precautions during the insertion of catheters, and poor patient and hand hygiene before catheter manipulation were associated with an increased risk of CRBSI (Table I).

The results of the multivariate analysis are broadly in agreement with the univariate analysis (Table II). In multivariable analysis, a high APACHE II score (odds ratio [OR] = 1.10), duration of catheterization (OR = 1.08), an emergency situation applying at catheter insertion (OR = 5.45), poor patient hygiene (OR = 4.38), poor hand hygiene, and a failure to use maximal

TABLE II
Risk factors of CRBSI in patients with CVCs used for the administration of PN (multivariate analysis)

Risk factors	OR	95% CI
APACHE II	1.10	1.01–1.21
Duration of catheterization	1.08	1.02–1.15
Emergency situation at catheter insertion	5.45	1.20–24.82
High number of catheter manipulations	1.18	0.33–4.22
Catheterization by inexperienced personnel	3.59	0.89–14.36
Poor patient hygiene	4.38	1.39–13.78
Hand hygiene	0.28	0.09–0.88
Maximal sterile barrier precautions	0.26	0.08–0.93

APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; CRBSI, catheter-related bloodstream infection; CVC, central venous catheter; PN, parenteral nutrition.

TABLE III
Microorganisms isolated from CRBSI

Microorganisms	n	%
Gram-negative microorganisms	15	48.4
P. aeruginosa	4	12.9
Acinetobacter spp	4	12.9
Enterobacter spp	3	9.7
Klebsiella spp	2	6.5
E. coli	1	3.2
S. maltophilia	1	3.2
Gram-positive microorganisms	11	35.5
Coagulase-negative staphylococci	6	19.4
S. aureus	4	12.9
Enterococcus spp	1	3.2
Candida spp	5	16.1
Candida albicans	2	6.5
Candida spp non-*albicans*	3	9.7

CRBSI, catheter-related bloodstream infection.

barrier precautions were determined to be risk factors for CRBSI. Hand hygiene before catheter manipulations and maximal barrier precautions during the insertion of catheters substantially reduced CRBSI levels, to 72% and 74%, respectively (Table II).

Thirty-one microorganisms were isolated as etiological agents for CRBSI (Table III). Eleven (35.5%) Gram-positive cocci, 15 (48.4%) Gram-negative bacilli, and 5 (16.1%) *Candida* spp were isolated as causes of CRBSI. The most frequent isolated microorganisms were coagulase-negative staphylococci at 19.4%, *Staphylococcus aureus* at 12.9%, *Pseudomonas aeruginosa* at 12.9%, and *Acinetobacter* spp. at 12.9% (Table III).

DISCUSSION

CRBSI is the most serious and common problem of CVC use, carrying with it a high level of morbidity and mortality, and increasing the cost of medical treatment and length of hospitalization.[1,8] The population impact of intravascular catheters as an infection risk is reflected by the fact that almost all (92%) episodes of infection were acquired during this form of access.[12] Previous studies have shown that indwelling of CVCs is an important risk factor for nosocomial bloodstream infections.[1–13,16]

The National Nosocomial Infections Surveillance System reported CRBSI rates ranging from 1.8 to 5.2 per 1000 catheter-days.[17] Some studies have reported an incidence of CRBSI ranging from 0.33 to 20.06 per 1000 catheter-days.[3–8] The rate of CRBSI obtained during our study is among the high CRBSI rates in the literature, which could be attributed to the risk factors in high number ($p < .0001$). The rate of CRBSI rises as the number of risk factors increases.[9]

Catheterization for central venous pressure measurement, PN, and hemodialysis are major risk factors for CRBSI.[5,8,18,19] Many different risk factors for CRBSI, such as a high number of catheter manipulations, emergency situations for catheter insertion, duration of catheterization, duration of PN infusion, and deficiencies in education related to the prevention of CRBSI, have been reported in the literature.[1,2,5,7–13,16,18–20] A high APACHE II score, prolonged catheterization, emergency situations for catheter insertion, a failure to use maximal barrier precautions during the insertion of catheters, poor patient hygiene, and poor personnel hand hygiene for catheterization were associated with increased risk of CRBSI at univariate analysis. We found that a high APACHE II score, prolonged catheterization, emergency situations at catheter insertion, poor patient hygiene, poor compliance with hand hygiene before catheter manipulation, and a failure to use maximal barrier precautions during the insertion of catheters were independent risk factors for CRBSI in the multivariable model.

Duration of catheterization has been suggested as an important risk factor in the development of CRBSI.[8,9,20] The risk of infection rises particularly during lengthy catheterization. In our study, the prolongation of catheterization by 1 day was determined to increase the risk of CRBSI by 1.08 times (OR, 1.08; 95% confidence interval [CI], 1.02–1.15; $p = .004$).

The risk of infection increases considerably if insertion takes place in emergency situations with suboptimal sterile field preparation. Such catheters should be removed or replaced within 24 hours.[1,10] We determined that CRBSI increased in emergency situations for catheter insertion. CRBSI in CVCs inserted in emergency conditions was determined to be 5.45 times greater than CRBSI in CVCs inserted under elective conditions (OR, 5.45; 95% CI, 1.20–24.82; $p = .016$).

Poor patient and personnel hygiene is another important risk factor for increased CRBSI.[13,18,21] Although some researchers have reported that a sterile procedure (handwashing, mask, cap, sterile gloves and field) may be sufficient, others concluded that more strict asepsis using maximum sterile barrier precautions (sterile scrub, caps, mask, sterile surgical gown, gloves, and large drapes) can significantly reduce infection risks.[10] Our results demonstrate that the incidence of CRBSI was reduced in patients by well-regulated hand hygiene before catheter manipulations. Our study indicated that in CVCs manipulated by health care workers giving attention to hand hygiene, CRBSI decreased by 72% (OR, 0.28; 95% CI, 0.09–0.88; $p = .0003$). Using maximum sterile barrier precautions reduced CRBSI by 74% (OR, 0.26; 95% CI, 0.08–0.93; $p = .017$). The rate of CRBSI increased by 4.38 times when patient hygiene was poor (OR, 4.38; 95% CI, 1.39–13.78; $p = .019$).

Authorities recommend that CVCs be placed in a subclavian site instead of a jugular or femoral site to reduce the risk for infection.[1,2] No statistical difference between catheter locations was found in our study, which was due to the low number of jugular and femoral catheterization.

Most of the microorganisms implicated in CRBSI arise from the skin flora.[1,2] Gram-positive microorganisms have become the most frequently (40%–70%) isolated pathogen associated with CRBSI.[1,2] Although Gram-positive microorganisms are the most frequent agent in CRBSI, in CRBSI-related infusion such Gram-negative microorganisms as *Enterobacter* spp, *Pseudomonas* spp, *Citrobacter* spp, *Serratia* spp, and *Candida* spp are the most frequent agents.[1,2] Our study demonstrated that the microorganisms most frequently iso-

lated as the cause of CRBSI were Gram-negative. We think this is because most of our patients are in the intensive care unit, where Gram-negative bacteria can thrive very easily. Microorganisms presumably were able to contaminate infusion fluid by transmission through the air, entering the infusion fluid when injections were administered through the infusion set, or entering through the hub of the catheter when the infusion set was changed. Microorganisms might also be transmitted unintentionally to the patient by medical care personnel.[1,2,22] Prolonged catheterization and number of catheter manipulations increase contamination. Good patient hygiene and personal hygiene may thus help reduce CRBSI originating from the administration of PN.

CONCLUSION

In conclusion, this prospective study shows that CVCs used for administration of PN are associated with a high rate of infectious complications. Our results demonstrate that the risk factors of CRBSI increased with a high APACHE II score, a cumulative number of risk factors, prolonged catheterization, emergency situations at catheter insertion, poor patient hygiene, poor hand hygiene, and the failure to use maximal sterile barriers. To inhibit CRBSI, health workers and patients must be trained on hygienic measures, the appropriate use of sterile barriers, short catheterization duration, and catheterization in case of emergency. Hygienic measures such as handwashing and the use of hand alcohol should be implemented before any use of CVCs.

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