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Evaluation of Infections Associated with Central Venous Catheters in ICU

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Abstract

Objective: Central venous catheter-related infections lead to an increase in widespread antibiotic use, prolonged hospital stays, increased costs, as well as morbidity and mortality. In this study, we aimed to evaluate the infections associated with central venous catheters used in our intensive care unit (ICU) and identify the possible contributing factors.

Methods: The hospital records of patients aged 18 and above who were admitted to ICU and had central venous catheters (femoral, jugular, and subclavian catheters) were retrospectively evaluated. Patients' demographic data and also reason for admission, APACHE II score, duration of ICU stay, and 28-day mortality were recorded. Additionally, data on the time of catheter insertion, catheter site, catheter type, administration of blood and total parenteral nutrition (TPN) through the catheter, presence of catheter-related infection, identified pathogens, time of infection development after catheter insertion, and concurrent blood culture results were recorded.

Results: A total of 169 patients were included in the study, of whom 99 (58.6%) were male and 70 (41.4%) were female. The catheters were located in the femoral region in 56 (33.1%) cases, jugular region in 99 (58.6%) cases, and subclavian region in 14 (8.3%) cases. There was no significant difference in the development of catheter infection based on the site of application (p=0.929). The rates of infection were significantly higher in catheters used for TPN and blood transfusion (p=0.002 and p=0.005, respectively). The average duration of intensive care stay was significantly higher in patients who developed catheter infections.

Conclusion: Catheter-related bacteremia is an important risk factor for morbidity and mortality, especially in critically ill patients. In our study, no significant differences were found in the rates of catheter-related infection based on the application sites. We observed that the use of TPN, blood transfusion, and longer catheter duration posed risks for infection.

Key words: Catheter-Related Bacteremia, Central Venous Catheter, İntensive Care Unit

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INTRODUCTION

The use of central venous catheters is a commonly preferred practice in ICU for monitoring patients. It is often chosen for purposes such as fluid therapy, medication administration, blood transfusions, total parenteral nutrition (TPN) delivery, and monitoring of hemodynamic status, particularly in critically ill patients. However, central venous catheterization can lead to complications such as hemorrhage, infection, and thrombosis. The increasing frequency of catheter use in ICU also contributes to the higher rates of nosocomial infections and catheter-related sepsis (1-3). Central venous catheter-associated infections not only result in widespread antibiotic use, prolonged hospital stays, increased costs, but also lead to increased morbidity and mortality. Catheter-related bloodstream infections occur in approximately 1-13% of central catheters, and the incidence of bloodstream infections has been reported as 2-4.5 per 1000 catheter-days in studies. The choice of catheterization site, including femoral, jugular, and subclavian catheterization, varies depending on clinical preferences, although the literature yields different results regarding the risk of infection development associated with each site. Catheter material, site of insertion, paying attention to sterile precautions during insertion, and host defense are important for catheter infections. Furthermore, it has been suggested that the administration of blood and TPN infusions through the catheter may also contribute to the development of infections (3-5). In this study, we aimed to evaluate infections associated with central venous catheters used in our ICU and review the underlying reasons in accordance with the literature.

METHODS

After obtaining ethical committee approval and institutional permissions, our study was conducted by retrospectively evaluation of the medical records. We included the patients aged 18 and above who had central venous catheterization during ICU stay at between January 1, 2022, and December 31, 2022. We excluded the patients who were discharged or died within 48 hours after ICU admission, those with a diagnosis of malignancy, and those with immunodeficiency. Patient data including age, gender, comorbidities, reason for ICU admission, APACHE II score, duration of ICU stay, and 28-day mortality were recorded. Additionally, information regarding the timing of central venous catheter insertion, catheter site, catheter type, administration of blood and TPN through the catheter, presence of catheter infection, causative agents, time of infection development after catheter insertion, and

simultaneous blood culture results were recorded.

Statistical Analysis

We used Statistical Analysis IBM SPSS Statistics 20.0 (IBM SPSS, Chicago) software for statistical analysis of the data obtained in the study. Categorical variables were presented as frequencies and percentages, while continuous variables were presented as median (minimum-maximum). The normal distribution of variables was evaluated with the Kolmogorov-Smirnov test. Non-parametric Mann-Whitney U test was performed for comparisons between groups. We used the chi-square test while evaluating the categorical data. A p-value lower than 0.05 was considered statistically significant.

RESULTS

A total of 169 patients were included in the study, with 99 (58.6%) being male and 70 (41.4%) female. Table 1 presents the demographic data of the patients.

The average age of the patients was 68.83±19.28, with males having an average age of 66.90±18.31 and females 71.55±20.40. Among the patients, 18.9% had no comorbidities, while 81.1% had at least one diagnosed comorbidity. Common comorbidities included hypertension (51.47%), respiratory conditions such as asthma and chronic obstructive pulmonary disease (23.07%), diabetes mellitus (22.48%), neurological conditions such as Alzheimer's and cerebrovascular disease (21.30%), and cardiac diseases such as coronary artery disease and heart failure (18.34%). The main reasons for ICU admission were respiratory failure (34.3%), COVID-19 (20.7%), and multitrauma (17.2%). The 28-day mortality rate of the patients was 53.8%, with 54.5% in males and 52.9% in females. Central venous catheters were inserted on average 4.17±3.99 days after admission to the ICU. Among the inserted catheters, 56 (33.1%) were femoral, 99 (58.6%) were jugular, and 14 (8.3%) were subclavian. Of the catheters, 91.1% were central venous catheters, while 8.9% were hemodialysis catheters. The evaluation of infection development according to the sites of catheter application is presented in Table 2.

Table 1. Demographic data of the patients

Age (Mean±SD)		
	Male (n=99)	66,90±18,31
	Female (n=70)	71,55±20,40
Length of stay (day)		30,65±27,73
APACHE-II score		17,05±9,31
28 days-mortality		
	Male, n (%)	54 (% 54,5)
	Female, n (%)	37 (% 52,9)
Reason for admission, n (%)		
	Respiratory failure	58 (% 34,3)
	Covid-19	35 (% 20,7)
	Multitrauma	29 (% 17,2)
	Others	47 (% 27,8)
Co-morbidities		
	Hypertension	87 (% 51,47)
	Respiratory disease	39 (% 23,07)
	Diabetes mellitus	38 (% 22,48)
	Neurological diseases	36 (% 21,30)
	Cardiac	31 (% 18,34)
	Others	33 (% 19,52)
	None	32 (% 18,93)

There was no significant difference in the incidence of catheter-related infections based on the sites of application. The average time for infection development after catheter insertion

was 16.00±11.39 days, but it was not significantly different between the catheter sites. Simultaneous blood culture results indicated significant growth of bacteria. However, we couldn't find any significant difference in the comparison of blood culture results based on the catheter sites (Table 3). Furthermore, there was a significantly higher rate of infection development in catheters used for total parenteral nutrition and blood transfusions (Table 3). Regarding the causative agents of catheter infections, Gram-positive cocci (Coagulase-Negative Staphylococci and Staphylococcus spp.) were found in 53.9% of cases, Gram-negative bacilli (Acinetobacter spp., Klebsiella spp., Enterobacter spp., Pseudomonas spp., Proteus mirabilis, E. coli) in 41.2%, and Candida spp. in 0.4%. The causative agents in simultaneous blood cultures were Gram-negative bacilli (51.2%), Gram-positive cocci (43.5%), and Candida spp. (5.1%) (Table 4). The distribution of catheter infection causative agents according to the sites of application is shown in Table 5. Gram-positive cocci (Staphylococcus spp.) were found in 54.5% of femoral catheters, 55.5% of jugular catheters, and 40% of subclavian catheters. In our study, 42.9% of patients who developed catheter infections died within 28 days. Additionally, there was a significantly longer average length of ICU stay among patients who developed catheter infections (Table 3).

Table 2. Comparison of infection development according to the application sites of the catheters

Catheter site	n (%)	Age		Catheter infection			Time of catheter infection		Growth in the blood culture		
		ort±ss	p değeri	Yes (n/%)	No (n/%)	P value	Day (Mean±SD)	p value	Yes (n/%)	No (n/%)	P value
Femoral	56 (%33,1)	72,80 ± 19,89	0,047*	22 (%39,3)	34 (%60,7)	0,929	17,38 ± 11,42	0,656	10 (%45,5)	12 (%54,5)	0,130
Jugular	99 (%58,6)	66,83 ± 18,75		36 (%36,4)	63 (%63,6)		15,65 ± 11,83		25 (%69,4)	11 (%30,6)	
Subclaavian	14 (% 8,3)	67,07 ± 19,45		5 (%35,7)	9 (%64,3)		12,60 ± 8,93		4 (%80,0)	1 (%20,0)	

*p<0,05 statistically significant

Table 3. Evaluation of the relationship between catheter infections and usage patterns

		Catheter infection		
		Yes (n=63)	No (n=106)	P value
TPN	**Yes**	33 (%52,4)	30 (%47,6)	0,002*
	No	30 (%28,3)	76 (%71,7)	
Hemodialysis	**Yes**	10 (%15,9)	21 (%19,8)	0,522
	No	53 (%84,1)	85 (%80,2)	
Blood transfusion	**Yes**	53 (%84,1)	68 (%64,2)	0,005*
	No	10 (%15,9)	38 (%35,8)	
Growth in blood culture	**Yes**	39 (%61,9)	10 (% 9,4)	0,000*
	No	24 (%38,1)	96 (%90,6)	
Catheter type	**Central venous catheter**	60 (%95,2)	94 (%88,7)	0,147
	Hemodialysis catheter	3 (%4,8)	12 (%11,3)	
Co-morbidities	**No**	12 (%19,0)	20 (%18,9)	0,977
	Yes	51 (%81,0)	86 (%81,1)	
Length of stay in ICU		45,03±33,74)	22,11±19,00	0,000*

*p<0,05 statistically significant

Table 4. Microorganisms grown from the catheter culture and the blood culture taken simultaneously

Microorganism		Catheter culture(n/%)	Blood culture (n/%)
Gr (-) bacillus		26 (%41,2)	20 (%51,2)
	Klebsiella spp.	9	8
	Acinetobacter spp.	7	6
	Enterobacter spp.	6	4
	Pseudomonas spp.	2	1
	Proteus mirabilis	1	1
	E.coli	1	
Gr (+) cocci		34 (%53,9)	17 (%43,5)
	Stafilokok spp.	23	13
	Koagülaz Negatif Stafilakok	11	4
Candida spp.		3 (%0,4)	2 (%5,1)

Table 5. Microorganisms grown in culture according to catheter sites

Microorganisms		Femoral (n/%)	Jugular (n/%)	Subclavian (n/%)
Gr (-) bacillus		9 (%40,9)	15 (%41,6)	2 (%40,0)
	Klebsiella spp.	3	5	1
	Acinetobacter spp.	3	3	1
	Enterobacter spp.	2	4	-
	Pseudomonas spp.	-	2	-
	Proteus mirabilis	-	1	-
	E.coli	1	-	-
Gr (+) cocci		12 (%54,5)	20 (%55,5)	2 (%40,0)
	Stafilokok spp.	7	14	2
	Koagülaz Negatif Stafilakok	5	6	-
Candida spp.		1 (%4,5)	1(%2,7)	1(%10,0)

DISCUSSION

Catheter-related infections play a significant role among the complications associated with the use of central venous catheters. Central venous catheters are commonly used in the patients who were hospitalized for intensive care/palliative care. In these units, the length of stay for patients is often prolonged. Factors such as not changing the catheter at appropriate intervals, failure to be careful for asepsis-antisepsis precaution during catheter insertion, prolonged duration of catheterization, and ineffective catheter care pose a significant risk for infection (6,7). In a study conducted in the United States, it was stated that approximately 150 million central venous catheters are used each year, and 800,000 catheter-related bloodstream infections are observed. Furthermore, the study found that the attributed mortality rate for these infections ranges from 0-35% (8). In Europe, it has been reported that the rate of bloodstream infections in ICU is 3.7% (1.9/1000 patients), and 43.6% of these cases are attributed to intravenous catheters (5). In a study conducted in Turkey with the participation of 24 centers, catheter-related

bloodstream infection was found to be the most common healthcare-associated infection, with a 30-day mortality rate of around 27% (9). The development of catheter-related infections leads to prolonged hospital stays, increased mortality and morbidity rates and so health costs. In our study, it was observed that the rate of catheter-related infection was 37.2%, and the 28-day mortality rate in those with infection was 42.9%. Furthermore, the length of ICU stay was significantly higher in patients who developed catheter infections compared to those who did not. When looking at the literature, it is evident that our study results are similar to the results in developing countries, indicating that catheter-related infections increase ICU stay and mortality rates. When evaluating catheter-related infections based on the site of insertion, studies have reported varying results, but it is generally stated that the rates are higher in femoral regions (10,11). It has also been found that infections are less common in subclavian catheters compared to jugular and femoral catheters (2,12). In our study, when comparing infection rates based on the application sites, they were similar. The higher likelihood of infection in femoral catheters is often attributed to the flora and contamination of the region in previous studies (10-12). However, the lack of difference, as found in our study, could be attributed to the use of chlorhexidine-impregnated catheter dressings routinely used in our clinic.

The microorganisms isolated in catheter-related infections may vary depending on factors such as the patient's condition, the ICU where they are located, the site of catheter application, and the type of catheter. Studies have generally shown that Gram-positive cocci commonly found in the normal flora at the site of colonization, such as Staphylococcus aureus, Streptococcus spp., Staphylococcus epidermidis, Enterococcus spp., Corynebacterium spp., and Candida spp., are among the causative agents of infection (13,14).

However, recent studies have indicated an increasing frequency of Gram-negative bacteria such as Acinetobacter spp., Klebsiella spp., Pseudomonas spp., and E. coli (15,16). In our study, the most common pathogens were Gram-positive cocci, especially Staph spp. and Coagulase-negative Staphylococci, followed by Gram-negative bacteria, with Acinetobacter spp., Klebsiella spp., and Pseudomonas spp. being prominent within this group. This result suggests that the flora at the site of catheter insertion may contribute to catheter infections, similar with findings in the literature.

Additional risk factors such as the use of total parenteral nutrition (TPN) and duration of catheterization have been mentioned in studies regarding the development of catheter-related infections (2,17). It has been observed that the risk of infection increases by 4-fold for catheter durations between 7-14 days and by up to 5-fold

for durations exceeding 14 days. The same study found an association between the use of TPN and an increased risk of catheter-related infections (17). Similarly, studies have shown that the administration of blood transfusions also increases the incidence of catheter infections (18). In our study, significant increases in infection rates were observed in catheters with TPN infusion and blood transfusion. Additionally, infections occurred on average around the 16th day of catheter insertion, but there was no significant difference in infection development time based on catheter sites.

We can count some limitations for this study. Firstly, we designed the study as a retrospective research. Also, the narrow time interval for data collection and the inability to access all patient data from the hospital information management system are another limiting factors.

CONCLUSION

In conclusion, catheter-related bacteremia is a significant risk factor that increases mortality and morbidity, particularly in critically ill patients. Therefore, paying attention to aseptic-antiseptic conditions during the insertion of central venous catheters in both ICU and palliative care units, effective catheter care, and the use of barrier covers with antibacterial properties will help reduce catheter-related infections. Decreasing the incidence of catheter-related infections

Ethical Approval: Ethics committee approval was received for this study from Giresun Training and Research Hospital Clinical Research Ethics Committee with number KAEK/28.

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