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Evaluation of infection status of patients with acute renal failure according to catheter placement site: a retrospective study

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ABSTRACT

Aims: Acute renal failure (AKI) develops frequently in intensive care units, and hemodialysis (HD) is used for its treatment. Infections of catheters used in HD procedures directly affect patient care, workload, and cost. This study aimed to determine the infection status according to catheter placement in patients who developed ABF and received HD treatment.

Methods: The study was designed as a retrospective-descriptive study. The data collection form created by the researcher was applied to the files of 362 patients who completed their treatment in the intensive care unit of a hospital in İstanbul between November 2018 and October 2019. Ethics committee and institutional approval were obtained, and the study was initiated.

Results: Infection was observed in 52% of the femoral region, 27.1% in the jugular region, and 20.3% in the subclavian region. Diabetes (49.2%), hypertension (42.4%), intensive care unit length of stay of 15 days or more, use of 1% chlorhexidine in catheter care, and infection status were significantly different ($p<0.05$).

Conclusion: The femoral region has the highest rate of infection. Considering this rate, nurses should carefully perform catheter care and infection follow-up and take necessary precautions to prevent infection to reduce workload and catheter losses.

Keywords: Acute renal failure, catheter infections, central venous catheter care, hemodialysis catheters, hospital infections

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INTRODUCTION

Acute renal failure (AKI) is a clinical picture in which blood urea nitrogen (BUN) and creatinine values increase, and urine output decreases due to a rapid and severe decrease in the glomerular filtration rate. The development of AKI can occur within hours or weeks. Etiologic causes are listed as economic status, environmental factors, and age (Enç, 2020). Prerenal, renal, and post-renal problems are the causes of AKI (Yılmaz & Enç, 2023). Although it is a common complication, it is seen in 5-20% of intensive care unit patients. The mortality rate is between 35-65%. The occurrence of AKI in patients hospitalized in the intensive care unit poses a severe problem for patients, prolongs the length of hospitalization, and increases the cost of treatments such as dialysis (Gerkuş & Sivrikaya, 2020). Since AKI is a reversible clinical picture, hemodialysis (HD) is performed if the factors causing failure cannot be treated with medication (Enç, 2020). A suitable vascular access route is needed to perform HD. Temporary HD catheters are used in patients in urgent need of HD. The internal jugular vein is the most commonly used catheterization site, although femoral and subclavian veins are also used. Catheters have an essential place among vascular access alternatives and have life risks during insertion and significant complications in long-term use (Altındal et al. 2021). Infections are one of the most severe complications of prolonged catheter use. Multiple factors contribute to their occurrence, including the effect of pathogenic microorganisms, the duration of hospitalization, whether the catheter is inserted electively, the length of catheter use, catheter care, and location (Koştu & Ok, 2021). Bacteremia rate differs according to the catheter placement site. The femoral catheter is the highest. Most infections that are important in catheter losses occur due to the settlement of microorganisms in the skin at the catheter entry site and tip. Risk factors vary according to the type of catheter, number of lumens, insertion site, duration of use, and type of catheterization (Yüksel et al. 2020). Studies conducted to prevent catheter infections consider the catheter insertion procedure and catheter care and use essential. Despite refurbished catheters, staff training and aseptic technique are the most important ways to prevent catheter infection (Yüksel et al. 2020; Kıray et al. 2019). Central venous catheter (CVC) care and placement packages created by different

disciplines reduce the incidence of catheter infections. The antiseptic solution used in care also plays a vital role in catheter infections (Kıray et al. 2019). In this study, considering that catheter infections are an essential cause of catheter loss and catheter placement affects the infection rate, we aimed to investigate the infection status according to catheter placement in patients with acute renal failure receiving hemodialysis treatment.

Aim of the Work

This study aimed to investigate the infection status of patients with acute renal failure receiving hemodialysis treatment according to catheter placement.

METHODS

Ethical Aspect of Research

Permission was received from the İstanbul Beykent University Clinical Researches Ethics Committee (Date: 01.02.2019, Decision No: 2011-KAEK-50) and the Health Directorate. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The study was planned as a retrospective cross-sectional descriptive study.

Research Questions

- Is there a significant difference between catheter infection and sociodemographic characteristics of patients with hemodialysis catheters?
- Is there a significant difference between catheter infection and the location of the hemodialysis catheter?

Place and Time of Research

The study was conducted in the cardiovascular surgery intensive care unit of a training and research hospital in İstanbul between November 2018 and October 2019.

Population and Sample of the Research

The study population consisted of patients who were treated in the intensive care unit of a thoracic and cardiovascular surgery training and research hospital in İstanbul for one year, diagnosed with AKI, and received catheter HD treatment. A total of 362 patient files were analyzed, and the study was completed.

Method of Data Collection

A patient identification form was used to analyze the patient files. This form obtained demographic characteristics, systemic diseases, body-mass index (BMI), antibiotic use, surgical procedure site, use of ultrasound during catheter insertion, number of insertions, emergency or elective insertion, reason for change, frequency of care, antiseptic used in care, duration of intensive care unit stay, use of mechanical ventilator, and discharge information.

Analysis and Evaluation of Data

In the biostatistical analysis of the data obtained with the Patient Identification Form, the criteria were defined with mean, standard deviation, frequency, and percentage values. Chi-square and Fisher's exact probability tests were used to compare frequencies and percentages between groups. Student's t-test was used to compare the means of normally distributed variables between two groups. A significance limit of $p<0.05$ was taken for interpretation. SPSS (version: 23) package program was used for biostatistical analysis.

RESULTS

Table 1 shows the frequency distribution of the subjects (n=362) included in the study. The mean age of the individuals included in the study was 63 years, and according to the analysis performed with studen's t-test, no significant difference was found between infection status and mean age ($p=0.669$). In the study, 59.9% of the cases were male, and 40.1% were female, and there was no significant difference between gender (male/female) and the presence of infection ($p=0.291$). 79.6% of the cases were married, 20.4% were single, 13.8% were literate, 46.7% were in primary school, 17.1% were in secondary school, 17.7% were in high school, and 4.7% were in university and above. 15.2% were employed, 55.2% were retired, 29.6% were housewives, and all had health insurance. According to the presence of systemic diseases, 52.8% had systemic diseases, 26% had diabetes, and 29.3% had hypertension. Regarding BMI, 7.7% were underweight, 73.5% were average, and 18.8% were overweight or obese.

Table 1. Descriptive values of categorical variables of the cases

Variables		Frequency	Percentage
Gender	Male	217	59.9
	Female	145	40.1
Marital status	Married	288	79.6
	Single	74	20.4
Education	Literate	50	13.8
	Primary school	169	46.7
	Middle school	62	17.1
	High school	64	17.7
	University and above	17	4.7
Employment status	Employee	55	15.2
	Retired	200	55.2
	Housewife	107	29.6
Health insurance	Yes	362	100.0
Systemic disease	Yes	191	52.8
	No	171	47.2
DM	Yes	94	26.0
	No	268	74.0
Hypertension	Yes	106	29.3
	No	256	70.7
BMI	Weak	28	7.7
	Normal	266	73.5
	More and above	36	18.8

DM: Diabetus mellitus, BMI: Body-mass index

Table 2 shows the difference between information on catheter infection and systemic disease and the treatment process of the study's patients. According tox the Chi-square test, there is a significant difference between diabetes, BMI, surgical procedure, intensive care unit stay duration, femoral catheter, chlorhexidine, and presence of catheter infection ($p<0.05$). The frequency of diabetes mellitus (DM) in the infected

subgroup (49.2%) was higher than the DM level in the non-infected subgroup (21.5%), which is a significant difference finding. When we look at the subgroup with infection, the rate of infection is higher in those with normal BMI compared to those with underweight and overweight. When the presence of surgical procedures and infection are analyzed, this rate (100%) is high. When the subgroups of the intensive care unit length of stay variable were evaluated regarding infection, the infection rate in patients hospitalized for five days or more was 100%. No significant difference was found between the distributions of the subgroups for the variables of whether the patient was connected to a mechanical ventilator and antibiotic use (p>0.05).

Table 2. The difference between catheter infection and systemic disease and treatment process

	No infection		Infection present			
	n	%	n	%	c^2	p
DM						
No	238	78.5	30	50.8	19.71	0.0001
Yes	65	21.5	29	49.2		
BMI						
Weak	19	6.3	9	15.3	13.86	0.001
Normal	234	77.2	32	54.2		
More and above	50	16.5	18	30.5		
Surgical operation						
No	53	17.5	0	0	12.09	0.001
Yes	250	82.5	59	100		
Antibiotic use						
No	8	2.6	0	0		0.4*
Yes	295	97.4	59	100		
Duration of intensive care hospitalization						
≤4 days	88	29.0	0	0	22.63	0.0001
≥5 days	215	71.0	59	100		
Mechanical ventilator						
No	12	4.0	0	0		0.2*
Yes	291	96.0	59	100		
Catheter placement						
Jugular	142	46.9	16	27.1	66.12	0.0001
Subclavian	132	43.6	12	20.3		
Femoral	29	9.6	31	52.5		
Catheter care solution						
1% chlorhexidine	173	57.1	43	72.9	5.11	0.02
10% povidone iodine	130	42.9	16	27.1		

DM: Diabetes mellitus, BMI: Body-mass index, *Fisher

Table 3 shows the difference between catheters inserted in the jugular region and catheter infection in the patients included in the study. According to the Chi-square test, there was a significant difference between diabetes and duration of intensive care unit stay and the presence of catheter infection (p<0.05). The frequency of DM in the infected subgroup (43.8%) was similar to the DM level in the non-infected subgroup (16.2%). When the subgroups of the intensive care unit length of stay variable were evaluated regarding infection, the infection rate in patients hospitalized for five days or more was 100%. No significant difference was found between the distributions of the subgroups for the variables of whether the patient was connected to a mechanical ventilator, the presence of surgical procedures, and antibiotic use (p>0.05). Statistical interpretation cannot be made due to using povidone-iodine in caring for all catheters inserted in the jugular region.

Table 3. The difference between catheter infection and systemic disease and treatment process of catheter inserted in the jugular region

	No infection		Infection present			
	n	%	n	%	c^2	p
DM						
No	119	83.8	9	52.6	5.41	0.02
Yes	23	16.2	7	43.8		
Surgical operation						
No	22	15.5	0	0		0.13*
Yes	120	84.5	16	100		
Antibiotic use						
No	4	2.8	0	0		1.00*
Yes	138	97.2	16	100		
Duration of intensive care hospitalization						
≤4 days	38	26.8	0	0	4.26	0.04
≥5 days	104	73.2	16	100		
Mechanical ventilator						
No	8	5.6	0	0		1.00*
Yes	134	94.4	16	100		
Catheter care solution						
1% chlorhexidine	-	-	-	-	-	-
10% povidone iodine	142	100	16	100		

*Fisher, DM: Diabetes mellitus

Table 4 shows the difference between catheters inserted in the subclavian region and catheter infection in the patients included in the study. According to the Chi-square test, there was a significant difference between the duration of intensive care unit stay and the presence of catheter infection (p<0.05). When the subgroups of the intensive care unit length of stay variable were evaluated regarding infection, the infection rate was 100% in patients hospitalized for five days or more. No significant difference was found between the distributions of the subgroups for the variables of diabetes, use of a mechanical ventilator, presence of surgical procedure, and antibiotic use (p>0.05). Statistical interpretation cannot be made because povidone-iodine is used for all catheters inserted in the subclavian region.

Table 5 shows the difference between catheters inserted in the femoral region and catheter infection in the patients included in the study. According to the Chi-square test, there was a significant difference between diabetes and duration of intensive care unit stay and the presence of catheter infection (p<0.05). The frequency of DM in the infected subgroup (61.3%) was similar to the DM level in the non-infected subgroup (20.7%). When the subgroups of the intensive care unit length of stay variable were evaluated regarding infection, the infection rate in patients hospitalized for five days or more was 100%. No significant difference was found between the distributions of the subgroups for the variables of whether the patient was connected to a mechanical ventilator, the presence of surgical procedures, and antibiotic

use (p>0.05). Statistical interpretation cannot be made due to the use of chlorhexidine in the care of all catheters inserted in the femoral region.

Table 4. The difference between catheter infection and systemic disease and treatment process of catheter inserted in subclavian region

	No infection		Infection present		c^2	p
	n	%	n	%		
DM						
No	96	72.7	9	75.0	0.0001	0.9
Yes	36	27.3	3	25.0		
Surgical operation						
No	29	22.0	0	0		0.12*
Yes	103	78.0	12	100		
Antibiotic use						
No	2	1.5	0	0		1.00*
Yes	130	98.5	12	100		
Duration of intensive care hospitalization						
≤4 Days	40	30.3	0	0	3.63	0.06
≥5 Days	92	69.7	12	100		
Mechanical ventilator						
No	3	2.3	0	0		1.00*
Yes	129	97.7	12	100		
Catheter care solution						
1% chlorhexidine	-	-	-	-	-	-
10% povidone iodine	132	100	12	100		

*Fisher, DM: Diabetes mellitus

Table 5. The difference between catheter infection and systemic disease and treatment process of catheter inserted in femoral region

	No infection		Infection present		c^2	p
	n	%	n	%		
DM						
No	23	79.3	12	38.7	10.16	0.001
Yes	6	20.7	19	61.3		
Surgical operation						
No	2	6.9	0	0		0.22*
Yes	27	93.1	31	100		
Antibiotic use						
No	2	6.9	0	0		0.23*
Yes	27	93.1	31	100		
Duration of intensive care hospitalization						
≤4 days	10	34.5	0	0	10.46	0.001
≥5 days	19	65.5	31	100		
Mechanical ventilator						
No	1	3.4	0	0		0.50*
Yes	28	96.6	31	100		
Catheter care solution						
1% chlorhexidine	29	100	31	100	-	-
10% povidone iodine	-	-	-	-		

*Fisher, DM: Diabetes mellitus

DISCUSSION

Many precautions and rules must be followed to prevent infection in hemodialysis catheters. Among these is selecting the most appropriate catheter placement site. The right internal jugular vein is the most appropriate site for temporary hemodialysis catheter placement (Kotwal et al. 2022). In this study, 362 patient files with temporary HD catheters diagnosed with ABF and receiving HD therapy were included. The mean age of the individuals included in the study was 63 years, and according to the analysis results, no significant difference was found between infection status and mean age (p=0.669). However, in the literature, being over 60 is considered a risk factor for infection (Yuan et al. 2022). In our study, there was a significant difference between diabetes, BMI, surgical procedure and duration of intensive care unit stay, femoral catheter and chlorhexidine, and the presence of catheter infection (p<0.05). When examined separately according to catheter placement sites, a significant difference was found between the presence of catheter infection and having a diagnosis of diabetes and the duration of intensive care unit stay for catheters inserted in the femoral and jugular regions (p<0.05). There was a significant difference between the duration of intensive care unit stay and the presence of catheter infection in catheters inserted in the subclavian region (p<0.05). A meta-analysis found a significant relationship between DM, having a catheter in the femoral region, and infection (Guo et al. 2024). This study found a significant association between DM and infection in catheters inserted in the femoral and jugular regions. Excess BMI (>25) is a risk factor for catheter placement and infection. However, in our study, a significant correlation was found between the occurrence of infection and average BMI (p<0.05).

The risk of catheter-related infection appears to be higher in individuals with femoral catheters (Jiang et al. 2016). In this study, the femoral region had the highest infection rate, with 52.5% among catheter sites. According to the study by Zhang et al. (2017) in China, the infection rate was 36.07% in the jugular region, 35.5% in the femoral region, and 30.63% in the subclavian region. In the same study, as a result of the analysis using multiple Logistic regression analysis, the femoral region was found to be more risky in terms of infection than the subclavian region (p=0.030) (Zhang et al. 2017). Nurses should evaluate catheters in the femoral region more carefully for signs of infection.

Duration of intensive care unit stay is an influential risk factor for catheter infections. In a study, it was found that there was a significant difference between the duration of intensive care stay and the development of infection (Tanrıverdi et al. 2021). It is similar to our study. Considering the presence of surgical procedures and the presence of infection, it is seen that this rate (100%) is high (Table 2). The individuals included in the study were patients who underwent cardiovascular surgery. Cardiac surgery is a complex surgery and leads to a weakened immune system and increased risk of infection (Subramani, 2020). Microorganisms can quickly enter the catheter site of patients with weakened immune systems because the skin integrity is disrupted. The catheter entry site of operated patients should be regularly evaluated for signs of infection. (Reindl-Schwaighofer et al. 2020).

Since all catheters in our study were serviced twice daily, no statistical interpretation can be made. It is known that catheter dressings should be performed at certain intervals, but in cases of loosening, wetting, contamination, bleeding, etc., maintenance should be performed again (National Vascular Access Management Guide 2019). The retrospective nature of our study and insufficient catheter maintenance records limit the comments on this issue (İşeri et al. 2019). The catheterization procedure was performed in all cases without the use of USG. For this reason, statistical interpretation cannot be made.

When 1% chlorhexidine and 10% povidone-iodine used in catheter care in our study were evaluated in terms of infection status, there was a significant difference in favor of 1% chlorhexidine (p=0.020). In our study, the femoral catheter was maintained with 1% chlorhexidine, and the jugular and subclavian catheters were maintained with 10% povidone-iodine. In addition, all catheter care was performed using a gauze dressing. In a study, it was found that 20% of patients treated with 1% chlorhexidine gluconate, 9.5% of patients treated with 2% chlorhexidine gluconate, 13.6% of patients treated with 4% chlorhexidine gluconate and 58.3% of patients treated with 70% alcohol had growth (Özen et al. 2020). The study by Aslan et al. showed that the infection rate decreased significantly in the group dressed with chlorhexidine gluconate-impregnated nursing dressings (Aslan et al. 2020). In studies with a high level of evidence, it was found that most infections detected in adult intensive care units developed through catheters inserted in the femoral region, and it was concluded that the use of the femoral region should be avoided (Acun & Çalışkan, 2021). Our study used 1% chlorhexidine gluconate only in catheters inserted in the femoral region. Therefore, it is not possible to compare with other sites. In the existing literature with a high level of evidence, it is reported that chlorhexidine gluconate with a concentration of >0.5% containing 70% alcohol is more effective in skin contamination than alcohol-containing antiseptic solutions and povidone-iodine in terms of skin antisepsis (Acun & Çalışkan, 2021).

Frequent and inappropriate antibiotic use, comorbid diseases, metabolic disorders, and ventilator use increase the development of infection (Şahin et al. 2019). There was no correlation between antibiotic use, mechanical ventilator use, and the presence of infection in the patients included in our study.

When the studies on catheter care are examined, the common opinion is the use of chlorhexidine as a skin absorbent. The appropriate patient profile recommends transparent drapes, hand hygiene, and maximum sterile barrier precautions. In our study, 1% chlorhexidine was used only on femoral catheters, and all dressings were gauze. We could not obtain information on whether maximum sterile barriers were used during maintenance and whether more than two catheters were maintained in one day.

Limitations

The incidence of infection can be reduced by implementing interventions with proven efficacy in preventing infections. Lee et al. (2018) showed that catheter-related infections decreased when care packages, including hand hygiene, sterile precautions, chlorhexidine use, and selecting the appropriate site for catheter placement were preferred. In the study conducted by Yazıcı & Bulut (2018), an infection prevention package was applied to patients hospitalized in the anesthesiology intensive care unit, and the results of this study were similar to the study conducted by Lee et al. (2018). Preventing catheter infection is one of the indicators of quality nursing care. With quality nursing care, the nurse workload decreases, and patients' hospitalization duration decreases (Kurt, 2018). These practices effectively reduce infection, shorten the length of hospital stay, reduce costs, and positively affect mortality and morbidity by reducing the incidence of infection. During the data collection process, it was impossible to follow and comment on the catheter care process due to the nature of the retrospective study. This was one of the limitations of our study.

CONCLUSION

In this study, hemodialysis catheters placed in the femoral region had the highest infection rate. Many factors, such as patient-specific factors, duration of hospitalization, and the presence of surgical procedures, affect this rate. Taking the necessary precautions will increase the quality of care by reducing catheter losses and the nurse's workload. Various nursing care practices affect central venous catheter-associated infections and are used to prevent infection. It is recommended that healthcare professionals conduct clinical trials with a high level of evidence investigating the effectiveness of these nursing care practices on infection, prepare clinical protocols that can guide central venous catheter care, and monitor these protocols regularly.

3 keypoints;

- Infection in hemodialysis catheters used to treat acute renal failure remains essential.
- The incidence of infection varies according to catheter placement.
- Taking the necessary precautions will increase the quality of care by reducing catheter losses and the nurse's workload.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the İstanbul Beykent University Clinical Researches Ethics Committee (Date: 01.02.2019, Decision No: 2011-KAEK-50).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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