Journal of
Cardiology & Cardiovascular
Surgery

Original Article

DOI: 10.51271/JCCVS-0063

Factors affecting the functional survival of catheters used in hemodialysis patients

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Cite this article: Gençer SB, Saygılı Yönem Ö, Köz S. Factors affecting the functional survival of catheters used in hemodialysis patients. *J Cardiol Cardiovasc Surg.* 2025;3(4):71-75.

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Received: 05/11/2025 ◆ **Accepted**: 20/12/2025 ◆ **Published**: 23/12/2025

ABSTRACT

Aims: Central venous catheters are essential for establishing temporary or permanent vascular access in patients undergoing hemodialysis. This study aimed to evaluate complications related to hemodialysis catheters and to identify factors influencing their functional duration.

Methods: A total of 193 adult patients who required hemodialysis catheterization were evaluated prospectively. Demographic characteristics, comorbidities, laboratory parameters, catheter type, insertion site, and the use of ultrasonographic guidance were recorded. Catheter patency and reasons for removal were analyzed.

Results: Catheter survival differed significantly by insertion site ($p<0.05$). Femoral catheters had shorter patency compared with catheters placed in the internal jugular or subclavian veins. Catheters inserted without ultrasonographic guidance were more frequently removed due to dysfunction ($p<0.05$). Other removal causes did not differ significantly according to the use of ultrasonography.

Conclusion: The study identified several factors influencing catheter longevity, in alignment with previously published findings. Femoral access, absence of ultrasonographic guidance, lower educational level, advanced age, elevated ferritin, and low albumin levels were associated with poorer outcomes.

Keywords: Central venous catheter, hemodialysis, vascular access

INTRODUCTION

The kidneys play an essential role in maintaining internal homeostasis through the elimination of metabolic waste, regulation of acid–base and water–electrolyte balance, blood pressure control, and detoxification of endogenous and exogenous substances.[1] When these functions become impaired, renal replacement therapies are required.Dialysis removes excess fluid and metabolic by-products that cannot be adequately excreted due to renal dysfunction.[2] It functions as an externally controlled artificial kidney and contributes to maintaining patient well-being and quality of life.[3]

Dialysis indications are commonly classified as acute kidney injury, chronic kidney disease (CKD) and conditions requiring extracorporeal clearance independent of renal failure. Hemodialysis is the most frequently used modality for renal replacement therapy in clinical practice. Its essential components include the dialysis machine, dialysate, and vascular access route. Central venous catheters (CVCs) provide either temporary or permanent vascular access for hemodialysis. Temporary access is typically obtained via catheterization of the internal jugular, subclavian, or femoral veins. Permanent access methods include arteriovenous fistulas, arteriovenous grafts, and tunneled catheters.[4] Some tunneled catheters and implanted ports may remain functional for several years,[5,6] and there are reports of hemodialysis catheters remaining patent for more than five years.[7,8] However, the ideal duration for maintaining such catheters is still uncertain.

This study aimed to evaluate complications associated with hemodialysis catheters and to identify factors influencing catheter longevity. Catheter-related complications are generally categorized as insertion-related events, flow dysfunctions, mechanical or structural problems, and catheter-associated infections. These categories were examined comprehensively.

METHODS

This study was conducted under the supervision of the Division of Nephrology, Department of Internal Medicine, Cumhuriyet University. This study has been approved by

the Clinical Researches Ethics Committee of Cumhuriyet University (Date: 09. 10. 2018, Decision No: 2018-10/01). The study adhered to the principles of the Declaration of Helsinki. The study was conducted prospectively.

Patients aged 18 years or older who underwent temporary or permanent hemodialysis catheterization between November 2018 and January 2020 were included. For each patient, the two most recent hemoglobin and C-reactive protein (CRP) values, as well as serum albumin, ferritin, and pre-dialysis creatinine levels, were collected from the hospital's electronic database. Demographic and clinical data—including age, sex, presence of chronic infection, educational level, comorbidities (diabetes mellitus, hypertension, heart failure), and body-mass index—were recorded.

Statistical Analysis

Procedure-related variables included the site of catheter insertion, use of ultrasonography, catheter material, insertion and removal dates, prophylactic antibiotic use, adherence to catheter-care protocols, catheter tip configuration, and catheter type (temporary vs. permanent). When catheters were removed, the date and reason for removal were documented. Patients were monitored daily for catheter function. All analyses were performed using SPSS version 22.0. Normality was evaluated with the Kolmogorov–Smirnov test. The Independent samples t-test was used when parametric assumptions were met; otherwise, the Mann–Whitney U test was applied. The Kruskal–Wallis test was used for comparisons involving more than two groups. Logistic regression analysis was employed for multivariate modeling, and categorical variables were analyzed using the Chi-square test. Statistical significance was defined as $p<0.05$.

RESULTS

A total of 193 patients (age range: 23–96 years; mean age: 69.43±15.28) were included. Of these, 60.6% (n=117) were undergoing hemodialysis for the first time. The most common catheter type was the non-tunneled internal jugular catheter. CKD was present in 46.1% (n=89). The prevalence of diabetes mellitus ($\chi^2=4.17$, $p=0.041$), hypertension ($\chi^2=6.65$, $p=0.010$), and heart failure ($\chi^2=4.88$, $p=0.024$) was significantly higher in patients with CKD.

Catheter survival differed significantly according to insertion site ($p<0.05$). Femoral catheters demonstrated shorter functional duration compared with those placed in the internal jugular or subclavian veins. Among first-time dialysis patients, the proportion of femoral catheters was higher than in chronic dialysis patients, but this difference was not statistically significant ($\chi^2=1.98$, $p=0.371$). Of the catheters that remained functional for more than 30 days, 61.7% (n=29) had been inserted under ultrasonographic guidance.

Although catheter survival differed across insertion sites, the distribution of removal reasons did not differ significantly by insertion site ($p>0.05$). Only 18.65% (n=36) of catheter removals were due to catheter-related complications. Additionally, 5.70% (n=11) were removed upon the recommendation of the infectious diseases department due to infections originating from other sites. A significant association was observed between the use of ultrasonography and the reason for catheter removal ($p<0.05$). Catheter malfunction was more frequent when USG guidance was not used. Malfunction occurred in 8.8% (n=10) of USG-guided insertions and 15.0% (n=12) of insertions performed without USG (Table 1).

Table 1. Impact of ultrasound guidance on reasons for hemodialysis catheter removal

			Ultrasound		Total
			Without	With	
Reason for catheter removal	Systemic infection	S	4	7	11
		%	5.0%	6.2%	5.7%
	Malfunction	S	12	10	22
		%	15.0%	8.8%	11.4%
	Catheter area bleeding or pain	S	1	2	3
		%	1.3%	1.8%	1.6%
	Patient request	S	1	6	7
		%	1.3%	5.3%	3.6%
	Cure	S	14	42	56
		%	17.5%	37.2%	29.0%
	Transition to fistula	S	13	17	30
		%	16.3%	15.0%	15.5%
	Transition to permanent catheter	S	8	8	16
		%	10.0%	7.1%	8.3%
	Long-term catheterization	S	1	2	3
		%	1.3%	1.8%	1.6%
	Exitus (ex)	S	26	19	45
		%	32.5%	16.8%	23.3%
Total		S	80	113	193
		%	100.0%	100.0%	100.0%

$X^2=15.67$, $p=0.047$

Analysis of the data revealed that the risk of catheter-related bacteremia was significantly higher in patients with femoral catheters compared to those with catheters placed at other sites (OR: 5.11; 95% CI: 1.17–22.42). Lower educational level was associated with an increased likelihood of infection compared to patients with higher education (OR: 0.055; 95% CI: 0.005–0.669). Additionally, older age was modestly but significantly associated with an increased risk of infection (OR: 0.842; 95% CI: 0.730–0.972).

No statistically significant association was observed between infection risk and comorbidities, sex, catheter placement setting, baseline hemoglobin, CRP, ferritin, or albumin levels, nor with the presence of diabetes mellitus or nasal colonization (Table 2).

Table 2. Factors significantly associated with the risk of catheter-related bacteremia

	Regression coefficient	SE	Sig.	Odds	95% CI	
					Lower	Upper
Age	-.172	.073	.019	.842	.730	.972
Catheter insertion site	1.633	.754	.030	5.118	1.168	22.422
Educational level	-2.902	1.276	.023	.055	.005	.669

SE: Standard error, CI: Confidence interval

Ferritin levels were analyzed in relation to the reasons for catheter removal among hemodialysis patients. A statistically significant difference was observed between patients whose catheters were removed due to clinical recovery, transition to arteriovenous fistula, or death ($p<0.05$). Specifically, patients who died had notably higher ferritin levels than those who underwent clinical improvement or fistula placement, suggesting a potential association between elevated ferritin and adverse outcomes (**Table 3**).

A significant association was found between pre-catheterization serum albumin levels and the underlying reasons for hemodialysis catheter removal. Among patients with albumin levels below 25 g/L, half of the catheters were removed due to patient death, while 14.3% were removed because of infection ($p<0.05$). In contrast, for patients with albumin levels ranging from 25 to 40 g/L, 16.8% of catheters were removed due to death and 11.2% due to catheter dysfunction. These results suggest that lower albumin levels may predispose patients to higher mortality and an elevated risk of catheter-related complications (**Table 4**).

DISCUSSION

Hemodialysis is a renal replacement therapy performed via a dialysis machine when the kidneys are unable to maintain their physiological functions. It remains one of the most frequently utilized modalities for both acute and CKDs. Compared to peritoneal dialysis and renal transplantation, hemodialysis continues to be the most commonly preferred treatment. The number of patients receiving renal replacement therapy in our country increases annually. In emergency situations, where patients do not have an established vascular access route, CVCs are the most frequently used option. In

Table 3. Association between ferritin levels and reasons for hemodialysis catheter removal

	n	Mean	Standard error	Minimum	Maximum	Results
Systemic infection	11	766.9091	720.68390	107.00	2000.00	KW=22.53
Malfunction	22	630.9545	662.05722	14.00	2000.00	p=0.004*
Catheter area bleeding or pain	3	326.3333	172.71460	129.00	450.00	
Patient request	7	773.5714	758.39454	20.00	2000.00	
Cure	53	401.9396	517.62619	12.00	2000.00	
Transition to fistula	30	316.3867	384.98233	28.00	1780.00	
Transition to permanent catheter	16	578.6875	706.00583	35.00	2000.00	
Long-term catheterization	3	1109.6667	885.53957	229.00	2000.00	
Ex	45	888.7333	768.01132	15.00	2000.00	
Total	190	589.9284	654.29857	12.00	2000.00	

Table 4. Association between serum albumin levels and hemodialysis catheter removal reasons

			Albumin levels			Total
			-25	25-45	+40	
Reason for catheter removal	Systemic infection	S	6	5	0	11
		%	14.3%	3.5%	0.0%	5.7%
	Malfunction	S	2	16	4	22
		%	4.8%	11.2%	50.0%	11.4%
	Catheter area bleeding or pain	S	0	3	0	3
		%	0.0%	2.1%	0.0%	1.6%
	Patient request	S	2	5	0	7
		%	4.8%	3.5%	0.0%	3.6%
	Cure	S	9	45	2	56
		%	21.4%	31.5%	25.0%	29.0%
	Transition to fistula	S	2	26	2	30
		%	4.8%	18.2%	25.0%	15.5%
	Transition to permanent catheter	S	0	16	0	16
		%	0.0%	11.2%	0.0%	8.3%
	Long-term catheterization	S	0	3	0	3
		%	0.0%	2.1%	0.0%	1.6%
	Ex	S	21	24	0	45
		%	50.0%	16.8%	0.0%	23.3%
Total		S	42	143	8	193
		%	100.0%	100.0%	100.0%	100.0%

this study, we evaluated the complications associated with these catheters, their functional survival, and the factors influencing their performance.

Among the 193 patients included in the study, 55.4% (n=107) were male and 44.6% (n=86) were female. This distribution is consistent with the data from the European Clinical Database, which collected information from 55 centers and included 10,984 patients, of whom 56.84% (n=6.244) were male and 43.16% (n=4.740) were female.

The use of ultrasound guidance during catheter insertion provides procedural facilitation and contributes to a reduction in potential complications. Previous studies have demonstrated that ultrasound guidance significantly decreases the failure rate of jugular and subclavian catheter placement (odds ratio 0.32; 95% confidence interval 0.18–0.55), reduces insertion-related complications (odds ratio 0.22; 95% confidence interval 0.10–0.45), and minimizes the requirement for multiple insertion attempts (odds ratio 0.60; 95% confidence interval 0.45–0.79).[9] Consistent with these findings, our study identified a statistically significant difference in catheter dysfunction among patients in whom ultrasound guidance was not utilized ($p<0.05$). These results indicate that the application of ultrasound during catheter placement positively affects catheter functionality and performance.

Of the 193 catheters inserted, only five were permanent tunneled catheters, whereas 188 were temporary non-tunneled catheters. In terms of insertion sites, 61.1% of catheters were placed in the jugular region, 25.9% in the femoral region, and 13% in the subclavian region. Due to the predominance of temporary catheters in our cohort, our findings were primarily compared with studies evaluating temporary catheter use.

A retrospective study involving 782 patients reported that 84.27% (n=659) had catheters placed in the jugular vein, 12.53% (n=98) in the femoral vein, and 3.19% (n=25) in the subclavian vein.[10] Femoral catheters were associated with a higher rate of dysfunction compared to internal jugular catheters (odds ratio 0.029; 95% confidence interval 0.005–0.179).

Other studies have reported no significant difference in infection incidence between internal jugular and subclavian catheters; however, femoral catheters exhibited higher rates of infection, thrombosis, and malposition, and these findings were statistically significant.[11] Similarly, in our study, catheter functional survival varied significantly according to insertion site ($p<0.05$), with femoral catheters demonstrating shorter functional survival than jugular and subclavian catheters.[12-14]

The relationship between catheter insertion site and infection risk has been consistently reported in the literature, with femoral catheters being associated with a significantly higher risk of infection compared to other access routes.

Regarding inflammatory markers, Hoen et al.[15] reported that elevated CRP values were a significant risk factor for bacteremia in chronic hemodialysis patients, irrespective of catheter site. Conversely, Thomson et al.[16] found no significant association between CRP levels and catheter-related complications. In our cohort, factors that significantly increased the risk of infection included femoral catheter placement, lower educational attainment, and advanced age. Other variables, including comorbid conditions, sex, insertion environment, baseline hemoglobin or CRP levels, presence of diabetes mellitus, and positive nasal cultures, were not significantly associated with infection risk.

Limitations

This study has several limitations. First, its retrospective design limits the ability to establish causal relationships and introduces the possibility of reporting bias due to reliance on medical records. Second, since the study was conducted at a single center, the generalizability of the findings to other institutions or patient populations may be limited. Third, the small sample size of patients with tunneled permanent catheters reduces the power of subgroup analyses. Additionally, patients under 18 years old, those in intensive care, individuals who declined participation, and patients with incomplete data were excluded, which may have introduced selection bias. Finally, the predominance of temporary catheters and variability in operator experience may have influenced the complication rates and catheter survival times.

CONCLUSION

This study offers a comprehensive analysis of the various factors that influence the functional longevity of hemodialysis catheters. It was found that the insertion site of the catheter plays a critical role in its functional patency, with femoral catheters demonstrating shorter functional lifespans compared to those inserted into the internal jugular or subclavian veins. Importantly, the use of ultrasound guidance during catheter placement was associated with a significant reduction in dysfunction rates, thereby enhancing the duration of catheter functionality.

Key factors such as advanced age, lower educational level, reduced serum albumin levels, and elevated ferritin concentrations were identified as major contributors to the development of complications in hemodialysis patients. In particular, low serum albumin levels were found to be a strong predictor of increased mortality, while higher ferritin levels were linked more closely with negative outcomes, including death, rather than successful clinical recovery or the transition to a fistula.

The findings of this study emphasize the heightened infection risk associated with femoral catheter insertion, especially in older patients. Additionally, the use of ultrasound guidance in catheter placement was shown to markedly reduce complication rates and improve overall functional outcomes.

In conclusion, the results of this research underscore the importance of considering clinical factors—such as the insertion site, age, serum albumin, and ferritin levels—when evaluating the risks and outcomes associated with hemodialysis catheter placement. Further studies are recommended to explore these factors in greater depth, with the goal of refining clinical protocols to improve patient care and minimize complications.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study has been approved by the Clinical Researches Ethics Committee of Cumhuriyet University (Date: 09. 10. 2018, Decision No: 2018-10/01).

Informed Consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. Participants were fully informed about the study's aims, procedures, potential risks and benefits, and their rights—including the right to withdraw at any time without consequence. All participants voluntarily signed a written informed consent form.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

The authors received no financial support for the conduct or publication of this research.

Author Contributions

All authors contributed significantly to the study's conception, design, data acquisition, analysis, and interpretation. All authors reviewed and approved the final version of the manuscript.

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