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Original Article

Differences in Neutrophil-to-Lymphocyte Ratio, Hemoglobin, and Ferritin Between Arteriovenous Shunt and Hemodialysis Catheter in Maintenance Hemodialysis Patients

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ABSTRACT

Background: Vascular access type may influence systemic inflammation and hematologic profiles in patients undergoing maintenance hemodialysis.

Objective: This study aimed to compare neutrophil-to-lymphocyte ratio, hemoglobin, and ferritin levels between patients using arteriovenous fistulas and hemodialysis catheters.

Methods: This cross-sectional analytical study included 128 patients undergoing maintenance hemodialysis, consisting of 85 patients with arteriovenous fistulas and 43 with hemodialysis catheters. Neutrophil-to-lymphocyte ratio and ferritin levels were compared using the Mann–Whitney U test, whereas hemoglobin levels were analyzed using the independent-samples t-test. Multiple linear regression was performed to assess the independent association between vascular access type and each laboratory parameter after adjustment for potential confounders.

Results: Patients using hemodialysis catheters had a significantly higher neutrophil-to-lymphocyte ratio than those with arteriovenous fistulas (median 4.92 vs. 4.13; p=0.049). Hemoglobin levels were also higher in the catheter group (8.82 ± 1.57 vs. 8.19 ± 1.62 g/dL; p=0.038). Ferritin levels were numerically higher among catheter users but were not significantly different in unadjusted analysis (p=0.154). After multivariable adjustment, hemodialysis catheter use remained independently associated with higher neutrophil-to-lymphocyte ratio, hemoglobin, and ferritin levels.

Conclusion: Hemodialysis catheter use was associated with higher inflammatory and hematologic biomarker levels compared with arteriovenous fistula use among patients undergoing maintenance hemodialysis.

Keywords: chronic kidney disease; hemodialysis; arteriovenous fistula; hemodialysis catheter; neutrophil-to-lymphocyte ratio; hemoglobin; ferritin.

Introduction

Chronic kidney disease (CKD) is a major global health challenge, affecting approximately 788 million adults worldwide and ranking among the leading causes of mortality and disability.[1] The increasing prevalence of end-stage kidney disease has resulted in a growing number of patients requiring maintenance hemodialysis

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(HD), despite substantial advances in kidney replacement therapy.[2] Patients receiving maintenance HD continue to experience high rates of cardiovascular events, infection, hospitalization, and premature mortality, with chronic systemic inflammation recognized as one of the principal mechanisms contributing to these adverse outcomes.[2–4]

Vascular access is fundamental to delivering effective maintenance HD. Current clinical guidelines recommend an arteriovenous fistula (AVF) as the preferred long-term vascular access because of its superior patency, lower infection risk, and lower incidence of access-related complications than central venous catheters (CVCs).[2,5] Nevertheless, CVCs remain widely used for urgent dialysis initiation, failure of permanent vascular access, or when AVF creation is not feasible.[2] Prolonged catheter use has been associated with biofilm formation, catheter-related bloodstream infection, thrombosis, endothelial injury, and persistent activation of the inflammatory response, potentially contributing to poorer clinical outcomes than AVF.[6–8]

Inflammation is highly prevalent among patients undergoing maintenance HD and contributes to anemia, malnutrition, accelerated atherosclerosis, cardiovascular disease, and increased mortality.[3,4] Conventional inflammatory biomarkers, including C-reactive protein (CRP) and interleukin-6 (IL-6), are well-established indicators of systemic inflammation but are not routinely available in many clinical settings because of their cost and limited accessibility.[9] Consequently, increasing attention has been directed toward inexpensive inflammatory biomarkers that can be derived from routine laboratory investigations. The neutrophil-to-lymphocyte ratio (NLR), calculated from a complete blood count, has emerged as a reliable marker of systemic inflammation and has been associated with adverse cardiovascular outcomes and all-cause mortality in patients receiving maintenance HD.[10–12] Hemoglobin and ferritin are also routinely monitored in HD patients to evaluate anemia management and iron status. Beyond its role as an iron-storage protein, ferritin acts as an acute-phase reactant, and chronic inflammation contributes to impaired erythropoiesis by disrupting iron metabolism and increasing hepcidin production.[13–15]

Several studies have demonstrated that catheter-based vascular access is associated with greater inflammatory activity than AVF. Crespo-Montero et al. reported higher inflammatory marker levels among patients with tunneled hemodialysis catheters than those with AVF. In contrast, Goldstein et al. observed increased inflammation even in the absence of catheter-related infection.[6,16] More recently, Yousefi et al. evaluated the association between vascular access type and malnutrition-inflammation-atherosclerosis syndrome but found no significant differences in ferritin concentrations between catheter and fistula users.[17] Although previous studies have examined selected inflammatory markers, evidence simultaneously evaluating NLR, hemoglobin, and ferritin according to vascular access type remains scarce. In addition, the independent association between vascular access type and these routinely available laboratory parameters has not been adequately investigated after adjustment for potential confounding factors.

We hypothesized that vascular access type is associated with differences in inflammatory and hematologic biomarkers among patients undergoing maintenance hemodialysis. Therefore, this study aimed to compare NLR, hemoglobin, and ferritin levels according to vascular access type among patients undergoing maintenance hemodialysis and to evaluate whether vascular access type was independently associated with these laboratory parameters after adjustment for relevant clinical confounders.

Methods

Study design and participants

A hospital-based cross-sectional analytical study was conducted at the hemodialysis unit of a tertiary referral hospital in Indonesia. The study included all eligible patients undergoing maintenance hemodialysis during May 2026. A total sampling approach was employed, whereby all patients who met the eligibility criteria during the study period were included.

Adult patients undergoing maintenance hemodialysis through either an arteriovenous fistula (AVF) or a hemodialysis catheter were eligible for inclusion. Patients with active infection, malignancy, autoimmune disease, hematological disorders, recent surgery or trauma, acute bleeding, or incomplete medical records were excluded because these conditions could influence inflammatory and hematologic biomarkers.

Data collection

Demographic and clinical data were obtained retrospectively from patients' medical records. Variables collected included age, sex, body mass index (BMI), smoking status, duration of hemodialysis, vascular access type, comorbidities, and medication use. Data regarding hypertension, diabetes mellitus, dyslipidemia, angiotensin-converting enzyme inhibitor (ACEI)/angiotensin receptor blocker (ARB) therapy, statin use, erythropoiesis-stimulating agent administration, and iron supplementation were also recorded.

Laboratory measurements

Laboratory data were obtained from routine blood examinations performed before the scheduled hemodialysis session. The neutrophil-to-lymphocyte ratio (NLR) was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count. Hemoglobin concentration (g/dL) and serum ferritin level (ng/mL) were retrieved from the corresponding laboratory records.

Outcome measures

The primary exposure variable was vascular access type, categorized as an arteriovenous fistula (AVF) or a hemodialysis catheter. The primary outcome measures were neutrophil-to-lymphocyte ratio, hemoglobin concentration, and serum ferritin level.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 27.0. Continuous variables were assessed for normality using the Shapiro-Wilk test. Normally distributed variables are presented as mean ± standard deviation (SD), whereas non-normally distributed variables are presented as median (interquartile range [IQR]). Categorical variables are expressed as frequencies and percentages.

Baseline characteristics were compared using the independent-samples t-test or the Mann-Whitney U test for continuous variables, as appropriate, and the chi-square test or Fisher's exact test for categorical variables.

Differences in NLR and ferritin levels between vascular access groups were analyzed using the Mann-Whitney U test, whereas hemoglobin levels were compared using the independent-samples t-test. Variables considered clinically relevant or showing a p value <0.25 in the bivariate analysis were entered into multiple linear regression models to evaluate the independent association between vascular access type and each outcome after adjustment for potential confounding variables. A two-sided p value <0.05 was considered statistically significant.

Ethical approval

This study was approved by the institutional Health Research Ethics Committee.

Results

Participant characteristics

A total of 128 patients undergoing maintenance hemodialysis were included in this study, comprising 85 (66.4%) patients with an arteriovenous fistula (AVF) and 43 (33.6%) with a hemodialysis catheter.

Baseline demographic and clinical characteristics according to vascular access type are presented in Table 1. The two groups were comparable in most baseline characteristics. Significant differences were observed in hypertension, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker (ACEI/ARB) use, and statin use between the AVF and hemodialysis catheter groups.

Table 1. Baseline characteristics of patients according to vascular access type

Variable	Total (N = 128)	AVF (n = 85)	HD catheter (n = 43)	p value
Demographic and clinical characteristics				
Age (years)	52.50 (19.00-96.00)	54.00 (22.00-96.00)	49.00 (19.00-83.00)	0.419
Sex, n (%)				0.286
Female	60 (46.9%)	37 (43.5%)	23 (53.5%)	
Male	68 (53.1%)	48 (56.5%)	20 (46.5%)	
HD frequency, n (%)				0.134
2 times/week	80 (62.5%)	57 (67.1%)	23 (53.5%)	
1 time/week	48 (37.5%)	28 (32.9%)	20 (46.5%)	
Duration of HD (months)	16.00 (4.00-159.00)	18.00 (4.00-121.00)	11.00 (4.00-159.00)	0.626
Access duration (months)	11.50 (1.00-134.00)	15.00 (1.00-123.00)	7.00 (1.00-134.00)	0.105
Etiology of CKD, n (%)				0.117
Diabetic nephropathy	35 (27.3%)	26 (30.6%)	9 (20.9%)	
Hypertensive nephropathy	86 (67.2%)	57 (67.1%)	29 (67.4%)	
Lupus nephritis	2 (1.6%)	1 (1.2%)	1 (2.3%)	
Unknown etiology	2 (1.6%)	1 (1.2%)	1 (2.3%)	
Obstructive uropathy	3 (2.3%)	0 (0.0%)	3 (7.0%)	
Comorbidities				
Hypertension, n (%)				0.021*
Yes	113 (88.3%)	79 (92.9%)	34 (79.1%)	
No	15 (11.7%)	6 (7.1%)	9 (20.9%)	
Diabetes mellitus, n (%)				0.325
Yes	40 (31.3%)	29 (34.1%)	11 (25.6%)	
No	88 (68.8%)	56 (65.9%)	32 (74.4%)	
Heart failure, n (%)				0.082

Variable	Total (N = 128)	AVF (n = 85)	HD catheter (n = 43)	p value
Yes	46 (35.9%)	35 (41.2%)	11 (25.6%)	
No	82 (64.1%)	50 (58.8%)	32 (74.4%)	
CAD/IHD, n (%)				0.717
Yes	8 (6.3%)	6 (7.1%)	2 (4.7%)	
No	120 (93.8%)	79 (92.9%)	41 (95.3%)	
Medication use				
ACEI/ARB, n (%)				0.015*
Yes	97 (75.8%)	70 (82.4%)	27 (62.8%)	
No	31 (24.2%)	15 (17.6%)	16 (37.2%)	
Statin, n (%)				0.046*
Yes	28 (21.9%)	23 (27.1%)	5 (11.6%)	
No	100 (78.1%)	62 (72.9%)	38 (88.4%)	
CCB, n (%)				0.128
Yes	83 (64.8%)	59 (69.4%)	24 (55.8%)	
No	45 (35.2%)	26 (30.6%)	19 (44.2%)	
Diuretic, n (%)				0.546
Yes	82 (64.1%)	56 (65.9%)	26 (60.5%)	
No	46 (35.9%)	29 (34.1%)	17 (39.5%)	
Beta blocker, n (%)				0.846
Yes	22 (17.2%)	15 (17.6%)	7 (16.3%)	
No	106 (82.8%)	70 (82.4%)	36 (83.7%)	
Aspirin, n (%)				0.750
Yes	11 (8.6%)	8 (9.4%)	3 (7.0%)	
No	117 (91.4%)	77 (90.6%)	40 (93.0%)	
ESA use within 4 weeks, n (%)				0.856

Variable	Total (N = 128)	AVF (n = 85)	HD catheter (n = 43)	p value
Yes	31 (24.2%)	21 (24.7%)	10 (23.3%)	
No	97 (75.8%)	64 (75.3%)	33 (76.7%)	
Iron therapy within 4 weeks, n (%)				0.670
Yes	27 (21.1%)	17 (20.0%)	10 (23.3%)	
No	101 (78.9%)	68 (80.0%)	33 (76.7%)	

Note: Data are presented as median (minimum-maximum) for non-normally distributed continuous variables and as frequency (percentage) for categorical variables. Comparisons between groups were performed using the Mann-Whitney U test for continuous variables and the Pearson chi-square test or Fisher's exact test, as appropriate. An asterisk (*) denotes statistical significance ($p < 0.05$).

Comparison of neutrophil-to-lymphocyte ratio, hemoglobin, and ferritin levels

Comparisons of neutrophil-to-lymphocyte ratio (NLR), hemoglobin, and ferritin levels between patients with different vascular access types are shown in Table 2. Patients using hemodialysis catheters had a significantly higher median NLR than those using AVFs (4.92 vs. 4.13, p = 0.049). Mean hemoglobin concentration was also significantly higher in the hemodialysis catheter group than in the AVF group (8.82 ± 1.57 vs. 8.19 ± 1.62 g/dL, p = 0.038). Ferritin levels were higher among patients with hemodialysis catheters; however, the difference was not statistically significant (p = 0.154).

Table 2. Comparison of study variables according to vascular access type

Variable	Total (N = 128)	AVF (n = 85)	HD catheter (n = 43)	p value
NLR	4.63 (0.02-55.18)	4.13 (0.02-16.11)	4.92 (1.28-55.18)	0.049*
Hemoglobin (g/dL)	8.40 ± 1.63	8.19 ± 1.62	8.82 ± 1.57	0.038*
Ferritin (ng/mL)	756.00 (23.00-3000.00)	754.00 (26.80-3000.00)	826.00 (23.00-3000.00)	0.154

Note: Hemoglobin level is presented as mean ± standard deviation (SD), whereas NLR and ferritin level are presented as median (minimum-maximum). Between-group comparisons were performed using the independent-samples t-test or the Mann-Whitney U test, as appropriate. An asterisk (*) indicates statistical significance ($p < 0.05$).

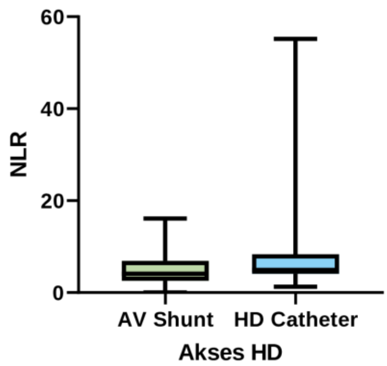

Figure 1. Box plot of neutrophil-to-lymphocyte ratio according to vascular access type

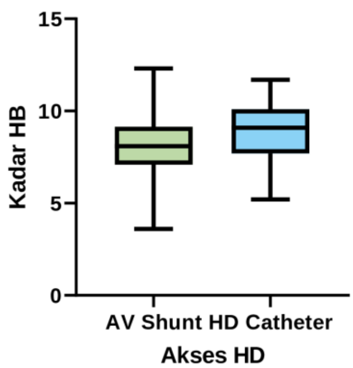

Figure 2. Box plot of hemoglobin levels according to vascular access type

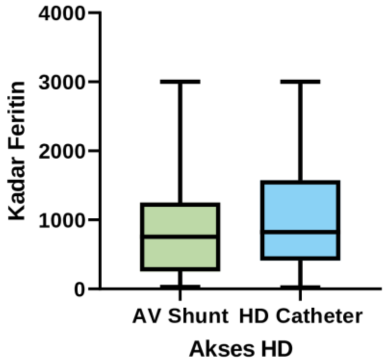

Figure 3. Box plot of ferritin levels according to vascular access type

Multivariable analysis

The associations between vascular access type and laboratory parameters after adjustment for hypertension, ACEI/ARB use, and statin use are presented in Tables 3-5. In the adjusted analyses, hemodialysis catheter use was significantly associated with higher NLR (B = 3.009, p = 0.020), higher hemoglobin concentration (B = 0.769, p = 0.016), and higher ferritin level (B = 307.050, p = 0.039).

Table 3. Multivariable linear regression analysis of factors associated with neutrophil-to-lymphocyte ratio

Independent variable	Unstandardized coefficient (B)	95% confidence interval	Standardized coefficient (β)	p value
		Lower to upper		
(Constant)	1.233	-5.424 to 7.890	—	0.715
Hypertension	-1.531	-5.289 to 2.228	-0.072	0.422
ACEI/ARB use	4.438	1.583 to 7.292	0.279	0.003*
Statin use	-1.492	-4.316 to 1.332	-0.091	0.298
Vascular access	3.009	0.486 to 5.531	0.209	0.020*

Note: An asterisk (*) indicates statistical significance at p < 0.05.

Table 4. Multivariable linear regression analysis of factors associated with hemoglobin

Independent variable	Unstandardized coefficient (B)	95% confidence interval	Standardized coefficient (β)	p value
		Lower to upper		
(Constant)	8.804	7.159 to 10.449	—	<0.005
Hypertension	-0.379	-1.307 to 0.550	-0.075	0.421
ACEI/ARB use	0.011	-0.695 to 0.716	0.003	0.976
Statin use	-0.571	-1.269 to 0.127	-0.145	0.108
Vascular access	0.769	0.146 to 1.392	0.224	0.016*

Note: An asterisk (*) indicates statistical significance at p < 0.05.

Table 5. Multivariable linear regression analysis of factors associated with ferritin levels

Independent variable	Unstandardized coefficient (B)	95% confidence interval	Standardized coefficient (β)	p value
		Lower to upper		
(Constant)	577.886	-190.539 to 1346.312	—	0.139
Hypertension	-6.000	-439.838 to 427.838	-0.003	0.978
ACEI/ARB use	93.542	-235.940 to 423.024	0.053	0.575
Statin use	-111.866	-437.842 to 214.109	-0.062	0.498
Vascular access	307.050	15.921 to 598.179	0.193	0.039*

Note: An asterisk (*) indicates statistical significance at $p < 0.05$.

Discussion

The present study evaluated the association between vascular access type and inflammatory and hematologic biomarkers among patients undergoing maintenance hemodialysis. Patients using hemodialysis catheters had significantly higher neutrophil-to-lymphocyte ratio (NLR) and hemoglobin levels than those using arteriovenous fistulas (AVFs). Although ferritin levels did not differ significantly in the unadjusted analysis, multivariable regression demonstrated that vascular access type remained independently associated with ferritin levels after adjustment for hypertension, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker (ACEI/ARB) use, and statin therapy. These findings support our hypothesis that vascular access type is associated with differences in inflammatory and hematologic biomarkers in patients receiving maintenance hemodialysis.

NLR is increasingly recognized as a readily available marker of systemic inflammation in patients with chronic kidney disease and has been associated with cardiovascular events, hospitalization, and all-cause mortality.[10–12] In the present study, patients using hemodialysis catheters had significantly higher NLR than those with AVFs, consistent with previous reports suggesting that catheter-based vascular access is associated with a greater inflammatory burden. Crespo-Montero et al. reported higher inflammatory marker levels among patients with tunneled dialysis catheters than among those with AVFs, while Goldstein et al. demonstrated persistent inflammation associated with catheter use even in the absence of overt catheter-related infection.[6,16] Chronic endothelial injury, biofilm formation, repeated vascular manipulation, and subclinical inflammatory activation associated with prolonged catheter use have been proposed as mechanisms contributing to sustained systemic inflammation.[6–8] Collectively, these findings reinforce current recommendations favoring AVFs as the preferred vascular access whenever clinically feasible.[2,5]

An unexpected finding of this study was the significantly higher hemoglobin concentration among patients using hemodialysis catheters. Chronic inflammation is generally associated with anemia through impaired erythropoiesis, increased hepcidin production, and reduced iron availability.[13–15] Therefore, lower hemoglobin levels might have been anticipated in catheter users. Several explanations may account for the present findings. First, differences in erythropoiesis-stimulating agent administration, intravenous iron therapy, or transfusion history, which were not evaluated in detail, may have influenced hemoglobin concentrations. Second, variability in clinical characteristics and treatment strategies between vascular access groups may have contributed to this observation. Finally, the cross-sectional design captures laboratory values at a single time point and cannot account for longitudinal changes in anemia management. Consequently, although vascular access type remained independently associated with hemoglobin concentration after adjustment for selected confounders, this finding should be interpreted cautiously and warrants confirmation in prospective studies.

Serum ferritin is routinely used to assess iron stores in patients receiving hemodialysis but also functions as an acute-phase reactant that increases during systemic inflammation.[13,14] In the present study, ferritin levels were numerically higher among catheter users, although the difference was not statistically significant in the unadjusted analysis. Interestingly, vascular access type became significantly associated with ferritin levels after multivariable adjustment, suggesting that confounding variables may have masked the relationship in the crude comparison. Similar findings have been reported by previous studies demonstrating that ferritin concentrations are influenced by both iron metabolism and inflammatory activity, limiting their specificity as an isolated marker of inflammation.[15,17] Therefore, ferritin should be interpreted in conjunction with other clinical and laboratory parameters when evaluating inflammatory status in patients undergoing maintenance hemodialysis.

The findings of this study have several clinical implications. Because NLR is inexpensive, readily available, and routinely derived from complete blood counts, it may serve as a practical adjunctive marker for identifying patients with increased inflammatory burden, particularly among those using hemodialysis catheters. Furthermore, the independent association between vascular access type and multiple laboratory parameters underscores the importance of optimizing vascular access whenever possible. Although vascular access selection should remain individualized according to patient characteristics and clinical feasibility, these findings provide additional evidence supporting the preferential use of AVFs in patients requiring long-term maintenance hemodialysis.[2,5]

This study has several strengths. It simultaneously evaluated inflammatory and hematologic biomarkers that are routinely measured in clinical practice and employed multivariable regression analysis to account for important clinical confounders.

Conclusion

This study demonstrated that vascular access type was associated with differences in inflammatory and hematologic biomarkers among patients undergoing maintenance hemodialysis. Compared with patients using an arteriovenous fistula (AVF), those using a hemodialysis catheter exhibited significantly higher neutrophil-to-lymphocyte ratio (NLR) and hemoglobin levels. Although ferritin levels did not differ significantly between the two groups in the unadjusted analysis, vascular access type remained independently associated with ferritin levels after adjustment for potential confounding factors. These findings suggest that vascular access type may influence inflammatory and hematologic profiles in maintenance hemodialysis patients and further support the clinical preference for AVF as the vascular access of choice whenever feasible. Future prospective multicenter studies with longitudinal follow-up and comprehensive assessment of inflammatory and anemia-related biomarkers are warranted to clarify the mechanisms underlying these associations and their impact on long-term clinical outcomes.

Limitations of the Study

However, several limitations should be acknowledged. First, the cross-sectional design precludes causal inference. Second, the study was conducted at a single tertiary referral center, which may limit the generalizability of the findings. Third, residual confounding cannot be excluded because detailed information regarding inflammatory markers such as C-reactive protein or interleukin-6, dialysis adequacy, erythropoiesis-stimulating agent dosage, intravenous iron therapy, and transfusion history was unavailable. Finally, the relatively modest sample size may have limited the statistical power to detect smaller differences between vascular access groups.

Declarations

Ethics approval and consent to participate

This study was approved by the institutional Health Research Ethics Committee.

Competing interests

The authors declare no conflicts of interest.

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Author's Contribution

Idea/concept: GFR. Design: GFR. Control/supervision: RTKD, DP, DR, EPP. Data collection/ processing: GFR. Analysis/interpretation: GFR. Literature review: -. Writing the article: GFR. Critical review: RTKD, DP, DR, EPP. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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