Neutrophil-to-Lymphocyte Ratio as a Prognostic and Comparative Parameter in Hemodialysis Patients: A Cross-Sectional Study

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Abstract

Background: Chronic kidney disease (CKD) is associated with complex hematological alterations, including lymphopenia, neutrophilia, and immune dysregulation with increased interest in neutrophil-to-lymphocyte ratio (NLR) which may act as a humble, practical prognostic and inflammatory marker. However, the intra-dialytic stability of NLR and the correlation between NLR and clinical outcomes in CKD patients remains inconsistent.

Methods: In this cross-sectional study, 200 patients with end-stage renal disease (ESRD) enduring maintenance hemodialysis (HD) at Aswan University Hospital were enrolled. For each patient, NLR was measured both pre and post dialysis session, allowing for paired comparisons. NLR values were subsequently examined according to anemic status, vascular access type, and mortality outcome. Independent predictors of mortality were then identified using logistic regression analysis.

Results: NLR remained stable across a single dialysis session (2.56 ± 1.58 pre-dialysis vs. 2.79 ± 2.65 post-dialysis, p = 0.126) and showed intermediate correlation between pre- and post-dialysis values (r = 0.583, R^2 = 0.340), more stable than its individual components, lymphocytes (R^2 = 0.325) and neutrophils (R^2 = 0.316). NLR did not vary significantly among anemic and non-anemic patients (2.56 ± 1.57 vs. 2.55 ± 1.74, p = 0.984). NLR was significantly higher amid non-survivors than survivors (3.17 ± 2.004 vs. 2.39 ± 1.39, p = 0.019). On multivariable analysis, an NLR > 4 was an self-regulating predictor of death (AOR = 3.200, ninty five percent CI: 1.243–8.237, p = 0.016), alongside a reduced left ventricular ejection fraction (EF) (<50%) (AOR = 2.941, ninty five percent CI: 1.193–7.250, p = 0.019). Overall mortality was 22%, predominantly cardiovascular and infectious.

Conclusion: NLR demonstrated stability across a single HD session and did not appear to be influenced by anemia status. However, it exhibited significant variation according to vascular access type and emerged as an sovereign predictor of death which supports the value of NLR as a simple, accessible prognostic sign in patients undergoing HD.

Keywords: Hemodialysis; chronic kidney disease; neutrophil-to-lymphocyte ratio...

INTRODUCTION

Chronic kidney disease (CKD) has arisen as 1 of the most projecting reasons of death and grief in the 21st century. The Global Burden of Disease (GBD) studies have demonstrated that CKD is a significant cause of worldwide mortality, despite the fact that the mortality rate in patients with end-stage renal disease (ESRD) has fallen ***(Kovesdy, 2022)***. many reports submit a wide difference in CKD occurrence across the region (4.7%–17.4%) ***(Liyanage et al., 2022, Wang et al., 2023)***. uncured, CKD can degrade and cause kidney failure needing transplantation or dialysis.

As per the 2020 Annual Data Report of the United States Renal Data System, approximately 808,000 individuals in the United States are either on dialysis (69 percent) or have undergone kidney transplants (31 percent) as a result of ESRD ***(Johansen et al., 2021)***. CKD causes fatigue, fluid retention, and sleep disturbances. Patients who are undergoing dialysis are faced with financial and spiritual challenges, as well as restricted diets and the inability to travel. These factors have a substantial impact on their quality of life ***(Yapa et al., 2021)***.In Egypt, CKD has arisen as a main reason of death, with its overall burden increasing markedly in recent years***(Farag and El-Sayed, 2022)***.

Beyond anemia, CKD is associated with complex hematological alterations driven by chronic inflammation, malnutrition, and accelerated atherosclerosis, resulting in neutrophilia, lymphopenia, and immune dysregulation***(Gameiro and Lopes, 2019)***. Full and gap white blood cell (WBC) counts are among the hematological markers potentially affected in CKD, and insistent low-grade inflammation has been known as an vital part of CKD pathogenesis. This has enlarged interest in the neutrophil-to-lymphocyte ratio (NLR) as a modest inflammatory marker***(Okyay et al., 2013)***. Raised NLR has been allied to increased mortality in cardiovascular disease (CVD)***(George et al., 2018b)***.

The reliability and affordability of novel inflammation signs resultant from peripheral blood cell analysis, as the NLR, monocyte-to-lymphocyte ratio (MLR), systemic immune-inflammation index (SII) , and platelet-to-lymphocyte ratio (PLR), have drawn considerable attention lately as a prognostic markers for a variety of chronic illnesses, including tumors and cardiovascular conditions***(Zhang et al., 2020)***. In ESRD patients requiring renal replacement therapy (RRT) for at least 6 months, MLR, PLR, and NLR measured at charge exhibited good analytical volume for 30-day all-cause mortality***(Mureșan et al., 2022)***.

NLR is the equilibrium among innate (neutrophils) and adaptive (lymphocytes) immunity. Increased levels of NLR reflect increased systemic inflammation and impaired immune regulation. Neutrophils are involved in acute inflammation and oxidative injury, whereas lymphocytes are involved in immunosurveillance and regulation. The NLR value has been strongly related to both mortality and inflammation and can serve as a interpreter of mortality in patients suffering dialysis***(Yang et al., 2023, Chandra et al., 2020)***. Researchers are finding its uses in several disorders, including kidney and CVDs, because of its easy acquisition way, low cost, and broad acceptance***(Afari and Bhat, 2016, Xie et al., 2022)***. High NLR values have been linked in studies with poor prognosis in most chronic diseases, such as CVDs, cancers, liver cirrhosis, autoimmune diseases, and sepsis.

Despite this background, the intra-dialytic stability of NLR and its relationship with vascular access, anemia status, and mortality outcomes remain insufficiently characterized. Thus, our work intended to assess the stability of NLR before and after a single HD session and its value as an independent predictor of death in HD patients.

Patients and Methods

Study Design and Setting

This cross-sectional study was conducted in the HD unit of Aswan University Hospital, Aswan, Egypt, from December 2023 to June 2025.

Patients

A entire of 200 adult patients diagnosed with ESRD and receiving regular HD were registered in the work.

Inclusion criteria

Patients aged ≥ eighteen years who had been enduring maintenance hemodialysis (MHD) for at minimum three consecutive months were eligible for participation, regardless of sex.

Exclusion criteria

Patients were excluded if they were pregnant or breastfeeding, or had polycystic kidney disease, autoimmune disorders, malignancy, inherited or acquired hematological diseases, acute or chronic inflammatory conditions, connective tissue disorders, clinically significant dehydration, or a recent history of hemorrhagic events. These criteria were applied to minimize potential confounding factors that could independently affect hematological parameters.

Laboratory and Clinical Assessments

All laboratory investigations were performed in the Clinical Pathology Department of Aswan University Hospital using standardized laboratory procedures and quality control protocols. Complete blood count (CBC) analysis was achieved utilizing an automated hematology analyzer. Paired venous blood samples were obtained closely before initiation of HD (pre-dialysis) and immediately after completion of a single dialysis session (post-dialysis). The following hematological indices were measured: hemoglobin, mean corpuscular volume (MCV), platelet count, total neutrophil count, WBC count, NLR, and lymphocyte count.

Transthoracic echocardiography was achieved for all partakers to assess left ventricular ejection fraction (EF).

Outcome Definitions

The primary outcome was all-origin death among hemodialysis patients during the study period, definite as death from any reason occurring after enrollment through the end of follow-up (June 2025). reason of death was considered as cardiovascular, infectious, cerebrovascular, or other, based on clinical and laboratory documentation.

A secondary outcome was the stability of the NLR across a single hemodialysis session, defined as the absence of a statistically significant alteration among paired pre-dialysis and post-dialysis NLR values. Additional secondary outcomes included the association of NLR with anemia status, vascular access type, and left ventricular ejection fraction, and the identification of independent predictors of death using multivariate and univariate logistic regression analysis.

Statistical Analysis

Statistical analyses were achieved utilizing IBM SPSS Statistics, version 29 (SPSS Inc., Chicago, IL, USA). The familiarity of continuous variables was evaluated utilizing both the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Paired t-tests (or the Wilcoxon signed-rank test, for variables not normally distributed) were employed to compare pre- and post-dialysis NLR values. Pearson correlation analysis was conducted to observe the association among pre- and post-dialysis NLR and other hematological parameters, with the coefficient of determination (R^2) derived from the corresponding correlation coefficients. Comparisons of NLR between anemic and non-anemic patients, as well as between survivors and non-survivors, were performed utilizing the Mann–Whitney U test or independent-samples t-test, as suitable. The Kruskal–Wallis test was applied to equivalence NLR across the different vascular access types. Predictors of mortality were evaluated through multivariate and univariate logistic regression analyses, with variables demonstrating a p-value < 0.10 on univariate analysis then arrived into the multivariate model. Results are expressed as odds ratios (OR) and familiar odds ratios (AOR), each accompanied by ninty five percent confidence intervals (CI). Statistical significance was distinct as a p-value < 0.05, and all tests were two-tailed.

Ethical Considerations

The work protocol was accepted by the Ethics Committee of the Faculty of Medicine, Aswan University, Egypt (Approval No. Asw.uni./523/3/21). Written informed consent was gotten from all participants previous to enrollment. Strict confidentiality and data protection measures were maintained throughout all phases of the study.

Results

Baseline Cohort Summary

A total of 200 adult patients receiving regular HD were registered in the work. The mean age of the cohort was 49.68 ± 15.535 years, with an approximately equal sex distribution and a slight predominance of females (50.5% female vs. 49.5% male). Body weight ranged widely from 15 to 130 kg, with a mean value of 70.43 ± 17.28 kg. Hypertension represented the most common underlying reason of CKD, accounting for 59% of cases, followed by idiopathic causes (17%) and diabetes mellitus (14%). Regarding vascular access, arteriovenous (AV) shunts constituted the predominant modality, used in 93% of patients, while temporary catheters and permanent catheters were used in 6.5% and 0.5% of patients, singly. The total mortality rate during the study period was 22% (**Table 1**).

Table 1: Baseline characteristics of the study cohort (n = 200)

Parameter	Category	Value
Age (years)	Mean ± SD	49.68 ± 15.535
Gender	Male / Female	49.5% / 50.5%
Weight (Kg)	Mean ± SD	70.43 ± 17.28
Cause of CKD	Hypertension	59%
	Idiopathic	17%

Parameter	Category	Value
	Diabetes mellitus	14%
Vascular access	AV shunt	93%
	Temporary catheter	6.5%
	Permanent catheter	0.5%
Mortality rate	Overall	22% (44/200)

NLR Change Across a Single Dialysis Session

Significant reductions were observed in platelet, total WBC, neutrophil, and lymphocyte counts following a single HD session, while NLR remained stable, with no statistically significant alteration among post-dialysis and pre-dialysis measurements (**Table 2**). Hemoglobin concentration also rose significantly after dialysis (9.59 ± 1.77 g/dL pre-dialysis vs. 10.015 ± 2.09 g/dL post-dialysis, $p < 0.001$), an expected finding attributable to hemoconcentration from ultrafiltration of plasma volume during the session rather than true erythropoiesis. The stability of NLR despite simultaneous reductions in neutrophil and lymphocyte counts suggests proportional changes in both cell populations, preserving the ratio. This relative stability supports the reliability of NLR as an inflammatory biomarker that can be measured either pre- or post-dialysis without materially affecting clinical interpretation.

Table 2: Hematological parameters before and after HD

Parameter	Pre-dialysis (Mean ± SD)	Post-dialysis (Mean ± SD)	p-value
Hemoglobin (g/dl)	9.59 ± 1.77	10.015 ± 2.09	<0.001*
MCV (fL)	84.24 ± 7.97	84.94 ± 7.77	0.022
Platelets (×10³/μL)	234.86 ± 75.012	220.089 ± 78.18	0.001
WBCs (×10³/μL)	7.103 ± 2.714	6.28 ± 2.71	<0.001
Neutrophils (×10³/μL)	4.14 ± 2.06	3.67 ± 2.37	0.002
Lymphocytes (×10³/μL)	1.84 ± 1.123	1.56 ± 0.74	<0.001
NLR	2.56 ± 1.58	2.79 ± 2.65	0.126

*Significant.

Stability Hierarchy of NLR Relative to Other Hematological Parameters

NLR demonstrated intermediate stability ($r = 0.583$, $R^2 = 0.340$). Importantly, it was more stable than its individual components — lymphocytes ($r = 0.570$, $R^2 = 0.325$) and neutrophils ($r = 0.562$, $R^2 = 0.316$) — likely due to proportional reductions in both cell lines during dialysis, while remaining less stable than MCV ($r = 0.852$, $R^2 = 0.726$) and the platelet and WBC counts (**Table 3**).

Table 3: Pearson correlation between pre- and post-dialysis hematological parameters

Parameter	r	R^2	p-value
MCV pre- and post-dialysis	0.852	0.726	<0.001
Platelets pre- and post-dialysis	0.629	0.396	<0.001
WBCs pre- and post-dialysis	0.628	0.394	<0.001
NLR pre- and post-dialysis	0.583	0.340	<0.001
Lymphocytes pre- and post-dialysis	0.570	0.325	<0.001
Neutrophils pre- and post-dialysis	0.562	0.316	<0.001

Stability hierarchy: MCV > platelets ≈ WBC > NLR > lymphocytes > neutrophils.

NLR According to Anemia Status

No statistically significant change was noted among anemic and non-anemic cases concerning NLR ($p > 0.05$) (**Table 4**).

Table 4: NLR according to anemia status

Parameter	Overall (n=200)	Anemia: Yes (n=185)	Anemia: No (n=15)	p-value
NLR pre-dialysis (mean ± SD)	2.56 ± 1.58	2.56 ± 1.57	2.55 ± 1.74	0.984

NLR and Ejection Fraction According to Mortality Outcome

The overall mortality rate was 22% (44/200 patients), predominantly attributable to cardiovascular disease (40.9%) and infectious causes (septic shock, infective endocarditis, and pneumonia, together 34.1%) (**Table 6**). The NLR of non-survivors was significantly higher than that of survivors (3.17 ± 2.004 vs. 2.39 ± 1.39, respectively, $p = 0.019$). Similarly, the EF in non-survivors was significantly lower than in survivors (53.80 ± 9.26% vs. 58.38 ± 10.49%, singly, $p = 0.009$) (**Table 5**).

Table 5: NLR and ejection fraction according to mortality outcome

Parameter	Overall	Non-survivors (n=44)	Survivors (n=156)	p-value
NLR pre-dialysis (mean ± SD)	2.56 ± 1.58	3.17 ± 2.004	2.39 ± 1.39	0.019*
Ejection fraction, % (mean ± SD)	57.37 ± 10.38	53.80 ± 9.26	58.38 ± 10.49	0.009*

*Significant.

Table 6: Causes of death among HD patients

Cause of death	n	Percentage (%)
Cardiovascular diseases	18	40.9%
Septic shock	6	13.6%
Infective endocarditis	5	11.4%
Pneumonia	4	9.1%
Cerebrovascular events	3	6.8%

NLR as a Predictor of Mortality: Univariate Analysis

In the unadjusted analysis, a reduced EF (<50%) was significantly associated with a higher mortality risk (OR = 3.024, ninety five percent CI: 1.351–6.770, p = 0.007). Similarly, patients with an NLR > 4 had approximately three times higher mortality risk than those with NLR ≤ 3 (OR = 3.051, 95% CI: 1.311–7.101, p = 0.010) (**Table 7**).

Table 7: Univariable logistic regression analysis of NLR and ejection fraction as predictors of mortality

Predictor variable	Category	OR	95% CI Lower	95% CI Upper	p-value
Ejection fraction (%)	≥ 50%	1	—	—	—
	< 50%	3.024	1.351	6.770	0.007*
NLR	≤ 3	1	—	—	—
	3.01–4	1.445	0.526	3.973	0.475
	> 4	3.051	1.311	7.101	0.010*

*Significant.

NLR as a Predictor of Mortality: Multivariable Analysis

On multivariable analysis, reduced EF (< 50%) (AOR = 2.941, 95% CI: 1.193–7.250, p = 0.019) and elevated NLR (> 4) (AOR = 3.200, 95% CI: 1.243–8.237, p = 0.016) arose as independent predictors of mortality amid hemodialysis patients (**Table 8**).

Table 8: Multivariable logistic regression analysis of NLR and ejection fraction as predictors of mortality

Predictor variable	Category	AOR	95% CI Lower	95% CI Upper	p-value
Ejection fraction (%)	≥ 50%	1	—	—	—
	< 50%	2.941	1.193	7.250	0.019*
NLR	≤ 3	1	—	—	—

Predictor variable	Category	AOR	95% CI Lower	95% CI Upper	p-value
	3.01–4	1.635	0.560	4.772	0.368
	> 4	3.200	1.243	8.237	0.016*

*Significant.

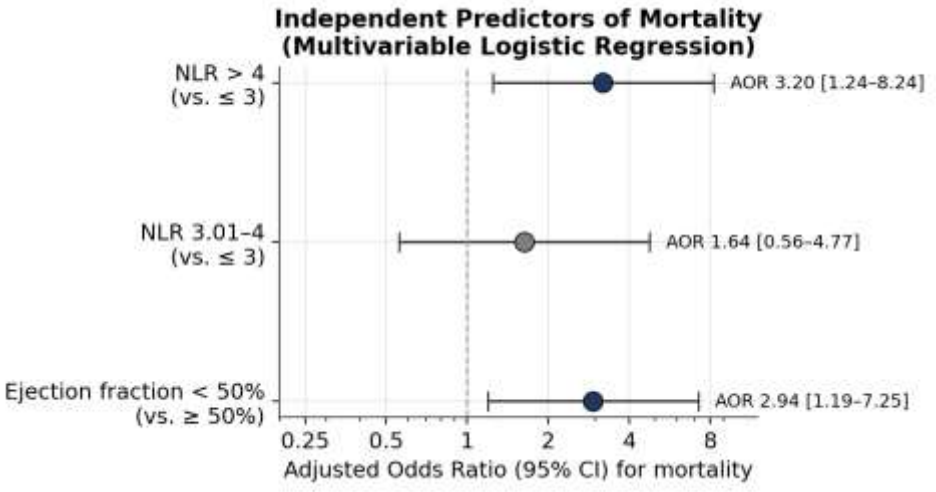

Figure 1: Forest plot of independent predictors of mortality.

Discussion

Our study provides a focused evaluation of the NLR as a comparative and prognostic parameter in a cohort of 200 patients with ESRD undergoing maintenance HD. Beyond confirming known short-term hematological alterations induced by HD, the study places NLR within a practical stability hierarchy of blood parameters and examines its behavior across clinically relevant subgroups.

HD induced significant reductions in platelet count, WBC count, neutrophils, and lymphocytes, consistent with prior studies***(Khader, 2012, Pandian et al., 2017)***. These changes are attributed to cellular activation, membrane interaction, complement activation, and transient sequestration in pulmonary and splenic circulation***(Khader, 2012, Albeshti et al., 2024, Effah et al., 2021)***. Despite significant reductions in neutrophils and lymphocytes, NLR remained stable across dialysis sessions. This reflects proportional declines in both cell populations, preserving the ratio despite absolute changes. These findings support NLR as a robust and practical inflammatory biomarker, consistent with prior evidence linking elevated NLR to systemic inflammation and adverse outcomes in CKD***(Effah et al., 2021, Okyay et al., 2013, George et al., 2018a)***. Its stability is particularly valuable in routine clinical settings where sampling timing may vary.

These results are reliable with a rising body of sign supportive NLR and related peripheral-blood-derived ratios as practical inflammatory and prognostic markers in CKD and HD populations. In ESRD patients demanding RRT for at least 6 months, MLR, NLR, and PLR measured at charge exhibited good predictive capacity for thirty-day all-cause mortality***(Mureșan et al., 2022)***. In a prospective study of 938 patients with CKD stages I–IV, patients with an NLR > 2.09 had a statistically significant rise in the development of ESRD***(Yuan et al., 2019)***. A higher MLR was similarly found to be a strong independent

predictor of cardiovascular and all-cause mortality in an HD cohort***(Xiang et al., 2018)***. A study conducted in Peru also found that CKD patients with raised PLR or NLR had double the probability of dying likened with those with normal ratios***(Umeres-Francia1 et al., 2021)***.

Patients with permanent catheters showed higher NLR compared with those using temporary catheters and AV shunts (4.69 [4.69–4.69] vs. 2.89 [2.41–4.77] and 2.26 [1.45–3.16], p = 0.049), while WBC count did not differ significantly (p = 0.634). This suggests increased inflammatory burden in catheter-dependent patients, likely due to subclinical infection, biofilm formation, or chronic foreign-body response. These findings support preference for AV fistulas due to lower infectious and inflammatory complications.

The overall mortality rate was 22%, with CVD (40.9%) and infections (34.1%) as leading causes of death, reflecting the combined cardiovascular and immune dysfunction burden in ESRD***(Briasoulis and Bakris, 2013)***. Multivariate analysis identified reduced left ventricular EF (<50%) and elevated NLR (>4) as independent predictors of mortality, emphasizing the main part of cardiac dysfunction and systemic inflammation in survival outcomes. Anemia-related variables and leukocyte abnormalities were not independently associated with mortality, suggesting that inflammation and cardiac dysfunction are stronger prognostic determinants than hemoglobin levels in this population. Consistent with this, NLR did not change amid anemic and non-anemic patients, indicating that its prognostic value is independent of anemia status.

Strengths and Limitations

Strengths of this work involve its fairly large sample size, paired pre-/post-dialysis measurements permitting dynamic assessment of NLR, and comprehensive evaluation of clinical and vascular access variables in relation to mortality. Limitations include the single-center design, limiting generalizability, and the cross-sectional design, limiting causal inference. Larger multicenter studies are wanted to further assess NLR's clinical utility in HD patients.

Conclusion

NLR is a relatively stable marker during HD, showing intermediate resistance to intra-dialytic variation compared to its components, and does not differ by anemia status. It varies significantly by vascular access type, being highest in patients with permanent catheters. Reduced left ventricular EF and elevated NLR (>4) were independent predictors of mortality on both univariate and multivariate analysis, supporting NLR's use alongside EF for risk stratification in HD patients.

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