

# Red Blood Cell Distribution Width as a Risk Factor for Late Arteriovenous Fistula Thrombosis in Maintenance Hemodialysis Patients: A Retrospective Cohort Study

Xi Chen, Mindong Chen, Zexin Lv, Jie Shen, Qian Jiang, Rong Zhou

Department of Nephrology, Yangpu Hospital, Tongji University School of Medicine, Shanghai, 200090, People's Republic of China

Correspondence: Rong Zhou, Email [zhourongyp@126.com](mailto:zhourongyp@126.com)

**Objective:** To investigate the predictive value of red blood cell distribution width (RDW) for late thrombosis in arteriovenous fistula (AVF).

**Methods:** A retrospective analysis was conducted on data from 50 patients with late AVF thrombosis admitted to Yangpu Hospital between June 2017 and May 2022 were collected. 60 patients with AVF but without thrombosis were recruited from the same institution during the same study period were selected as the control group. The correlation between RDW and other data was analyzed. Statistically significant risk factors were analyzed by multivariate logistic regression. The ROC curve was used to evaluate the value of RDW in predicting late AVF thrombosis.

**Results:** The values of RDW and leukocyte count in the thrombosis group were higher than those in the control group ( $P < 0.01$ ). The levels of CRP, PLR, NLR, and neutrophils in the thrombosis group were higher than those in the control group ( $P < 0.05$ ). Pearson correlation analysis showed that RDW was positively correlated with CRP, red blood cell count, PLR, NLR, and blood phosphorus. Multivariate logistic regression analysis showed that RDW (OR = 1.774, 95% CI: 1.055–2.983,  $P < 0.05$ ) was an independent risk factor for late AVF thrombosis. ROC curve analysis displayed that the area under the curve (AUC) for RDW was 0.702 (95% CI: 0.596–0.808,  $P < 0.001$ ). The optimal predictive cutoff value for RDW, calculated according to the Youden index, is 15.30%. Using RDW  $\geq$  15.30% to predict late AVF thrombosis yielded a sensitivity of 60.00% and a specificity of 98.30%.

**Conclusion:** RDW exhibits distinct expression patterns in late AVF thrombosis and demonstrates significant diagnostic potential. Incorporating this marker into existing diagnostic algorithms may enhance early risk prediction. However, further validation in large-scale, prospective multicenter studies is required to establish its clinical utility in routine practice.

**Keywords:** red blood cell distribution width, RDW, arteriovenous fistula, thrombosis

## Introduction

Maintenance hemodialysis (MHD) is a life-sustaining renal replacement therapy for patients with end-stage renal disease (ESRD), aimed at removing metabolic waste products, correcting electrolyte imbalances, and maintaining fluid homeostasis. A well-functioning vascular access is essential for delivering adequate hemodialysis in patients on maintenance hemodialysis (MHD). The rising prevalence of end-stage renal disease (ESRD) requiring hemodialysis has underscored the clinical importance of optimal vascular access selection. Owing to its advantages including technical simplicity, lower infection risk, and superior long-term patency,<sup>1</sup> the autogenous arteriovenous fistula (AVF), created by surgically anastomosing a native artery and vein, is the recommended first-choice vascular access for MHD. Dysfunction of the autogenous arteriovenous fistula (AVF), which is often regarded as the “lifeline” of MHD patients,<sup>2</sup> continues to be a leading cause of elevated hospitalization and mortality rates. As AVF is associated with superior long-term survival compared to alternative vascular access modalities, reserving AVF functionality is of paramount clinical importance.

A nationwide cohort study by Murakami et al demonstrated that AVF use is independently associated with reduced infection-related, cardiovascular, and all-cause mortality among patients undergoing maintenance hemodialysis.<sup>3</sup> Given that AVFs remain the recommended first-line vascular access, identifying modifiable risk factors for AVF failure—particularly late thrombosis—is essential for optimizing access longevity and improving clinical outcomes in this population.

Late AVF thrombosis, typically defined as thrombotic events occurring more than three months after fistula creation,<sup>4</sup> has an annual incidence of 0.1–0.5 events per year. It represents one of the most common complications of AVF and is a critical factor affecting the successful delivery of hemodialysis. Existing studies indicate that the one-year primary patency rate of AVF is approximately 60%–65%, while the two-year patency rate drops to only 48%–56%.<sup>5</sup> Dysfunction of the AVF, which is often regarded as the “lifeline” of MHD patients,<sup>2</sup> continues to be a leading cause of elevated hospitalization and mortality rates. Existing studies indicate that the one-year primary patency rate of AVF is approximately 60%–65%, while the two-year patency rate drops to only 48%–56%.<sup>5</sup> Late thrombosis of AVF is defined as thrombosis occurring after the fistula has matured and been used for more than three months.<sup>6</sup> It is a key factor contributing to access failure, significantly impairing dialysis quality and long-term survival, and has remained a persistent clinical challenge in the field of blood purification in recent years. Several demographic and clinical factors have been associated with an elevated risk of arteriovenous fistula (AVF) thrombosis. These include advanced age, distal AVF placement, elevated levels of inflammatory markers, hypertension, and so on.<sup>7</sup> Additionally, both acquired and genetic factors have been implicated, with patient comorbidities—including diabetes mellitus—and variations in vascular access type and location further influencing thrombotic risk.<sup>8</sup> Currently, there is a lack of effective monitoring indicators for the early prediction of late AVF thrombosis.

Red blood cell distribution width (RDW) is a laboratory parameter that reflects heterogeneity in red blood cell volume. A growing body of recent evidence has demonstrated significant associations between elevated RDW levels and the occurrence as well as prognosis of various thrombotic events, including pulmonary embolism, cerebral infarction, deep vein thrombosis, and coronary thrombosis, indicating its potential role as a predictive biomarker.<sup>9–11</sup> The underlying biomolecular mechanism of the relationship of RDW to thrombosis is largely unknown. One study suggests that increased blood cell contact with endothelial walls could trigger thrombosis by increased platelet and fibrin activation.<sup>12</sup> Yu FT et al found that anisocytosis could increase viscosity, causing more stagnant blood flow.<sup>13</sup> However, research on the predictive role of RDW in late AVF thrombosis remains limited. Therefore, this study aimed to investigate the risk factors for late arteriovenous fistula (AVF) thrombosis in patients undergoing hemodialysis. We hypothesized that specific clinical factors and hematological parameters, such as elevated red blood cell distribution width (RDW), would be significantly associated with an increased risk of late AVF thrombosis, potentially providing a theoretical basis for early identification and intervention.

## Materials and Methods

### Ethics Approval and Consent to Participate

This paper followed the Helsinki Declaration. This study was approved by the ethics committee of Yangpu Hospital, Tongji University School of Medicine (LL-2025-SCI-006). This study was approved by the same ethics committee with a waiver of informed consent. The reason for the waiver is as follows: This is a retrospective cohort study, and all data are derived from previous clinical records. The study subjects were not subjected to any interventions beyond routine clinical practice. Additionally, some of the data involve historical records, and a portion of the patients are lost to follow-up, making it impractical to re-obtain informed consent. All personal identification information and health data of patients will be de-identified. Research findings will be presented only in aggregate statistical form, ensuring no disclosure of personal privacy.

### Study Participants

The study design was a retrospective cohort study. Both case group and control group were drawn from the Department of Nephrology at Yangpu Hospital, Tongji University from June 2017 to May 2022.

50 patients diagnosed with late AVF thrombosis (thrombosis group) were included in this study. These patients, aged between 20 and 81 years (mean age  $61.27 \pm 13.69$  years). The primary renal diseases included diabetic nephropathy (19 cases, 38.0%), chronic glomerulonephritis (10 cases, 20.0%), and unknown etiology (21 cases, 42.0%).

150 patients with functional AVF met the inclusion criteria, from which 60 were randomly selected as the control group. The control group consisted of patients aged 20–80 years (mean age  $65.27 \pm 12.03$ ), with primary diseases including diabetic nephropathy (n=30), chronic glomerulonephritis (n=10), hypertensive nephropathy (n=8), and other causes (n=12). Polycystic kidney disease (n=1), obstructive nephropathy (n = 4), and unknown etiology (n = 7).

## Inclusion and Exclusion Criteria

### Inclusion Criteria

- (1) Diagnosed with end-stage renal disease and undergoing maintenance hemodialysis.
- (2) Using AVF as vascular access.
- (3) Meeting the diagnostic criteria for late AVF thrombosis.
- (4) Age  $\geq 18$  years.

### Exclusion Criteria

- (1) Comorbid malignancies, severe anemia, or recent use of glucocorticoids or immunosuppressants;
- (2) Concurrent acute infection;
- (3) Presence of non-renal anemia factors such as hemorrhagic anemia.
- (4) AVF thrombosis occurring within 3 months of fistula creation or last intervention.
- (5) Use synthetic graft or central venous catheter as the primary vascular access.
- (6) History of AVF surgical revision or endovascular intervention within 3 months prior to enrollment.

## Research Methods

Basic clinical data including gender, age, primary renal disease, and AVF vintage were collected from both groups. Fasting venous blood samples were collected pre-dialysis to measure complete blood count, C-reactive protein (CRP), albumin, serum calcium, serum phosphorus, intact parathyroid hormone (iPTH), and to calculate the platelet-to-lymphocyte ratio (PLR) and neutrophil-to-lymphocyte ratio (NLR).

## Statistical Analysis

Statistical analysis was performed using SPSS software (version 22.0). Measurement data conforming to normal distribution were represented by mean  $\pm$  standard deviation (Mean  $\pm$  SD). Independent sample *T*-test and analysis of variance were used for inter-group comparison. Pearson correlation analysis was applied to assess the relationship between RDW and other parameters. Multivariate logistic regression analysis found that previously significant variables were independent factors ( $P < 0.05$ ). With results were expressed as odds ratio (OR) and corresponding 95% confidence interval (CI). To evaluate the predictive effect of RDW on Late Thrombosis of Arteriovenous Fistula, a receiver operating characteristic (ROC) curve was constructed and the area under the curve (AUC), sensitivity, and specificity were calculated to show the predictive value of DPR. A  $P$ -value  $< 0.05$  was considered statistically significant, and  $P < 0.01$  indicated highly significant differences.

## Results

### Comparison of Clinical Data Between the Two Groups

No statistically significant differences were observed between the thrombosis and control groups regarding gender, age, AVF vintage, or history of diabetes (all  $P > 0.05$ ; Table 1).

Compared with the control group, patients in the thrombosis group exhibited significantly higher levels of CRP, neutrophil count, PLR, and NLR (all  $P < 0.05$ ). Additionally, RDW and white blood cell count were markedly elevated in the thrombosis group ( $P < 0.01$ ). No significant intergroup differences were found in platelet count, lymphocyte count, red blood cell count, hemoglobin, corrected serum calcium, serum phosphorus, iPTH, or albumin levels (all  $P > 0.05$ ; Table 1).

**Table 1** Comparison of Clinical Data Between the Two Groups

Characteristic	Thrombosis Group (n=50)	Control Group (n=60)	t/ $\chi^2$ Value	P value
Age (years)	35/15	40/20	0.078	0.938
Age (years)	61.27±13.69	65.27±12.03	0.078	0.938
AVF Vintage (months)	25.40±27.91	38.97±40.79	-1.392	0.167
History of Diabetes (%)	19 (38%)	30 (50%)	0.982	0.328
CRP (mg/L)	8.68±11.87	5.26±3.10	2.142	0.034
White Blood Cell Count ( $\times 10^9/L$ )	7.29±2.37	6.18±1.44	3.004	0.003
Neutrophil Count ( $\times 10^9/L$ )	6.59±9.33	4.13±1.07	2.024	0.045
Platelet Count ( $\times 10^9/L$ )	199.74±67.29	178.60±47.42	1.905	0.060
Lymphocyte Count ( $\times 10^9/L$ )	1.26±0.50	1.23±0.32	0.369	0.713
Hemoglobin (g/L)	109.94±12.06	114.93±12.06	-1.595	0.114
Red Blood Cell Count ( $\times 10^{12}/L$ )	3.86±0.85	3.71±0.43	1.202	0.232
RDW (%)	15.26±2.07	13.91±0.70	4.720	0.000
PLR	186.82±105.30	152.21±50.04	2.244	0.027
NLR	6.49±8.99	3.65±1.88	2.382	0.019
Corrected Calcium (mmol/L)	2.24±0.17	2.25±0.17	-0.111	0.912
Phosphate (mmol/L)	1.93±0.70	1.80±0.51	0.999	0.320
Parathyroid Hormone (pg/mL)	262.12±344.95	251.17±201.11	0.197	0.844
Albumin (g/L)	37.50±5.74	38.59±2.89	-1.060	0.291

## Correlation Analysis of RDW with Clinical Parameters

Pearson correlation analysis, with RDW as the dependent variable, revealed significant positive correlations with CRP ( $r = 0.277$ ,  $P = 0.004$ ), red blood cell count ( $r = 0.268$ ,  $P = 0.005$ ), PLR ( $r = 0.496$ ,  $P < 0.001$ ), NLR ( $r = 0.319$ ,  $P = 0.001$ ), and serum phosphorus ( $r = 0.268$ ,  $P = 0.005$ ) (all  $P < 0.01$ ). A weaker but statistically significant positive correlation was also observed between RDW and lymphocyte count ( $r = 0.268$ ,  $P = 0.005$ ). No other clinical parameters showed significant correlations with RDW ( $P > 0.05$ ; Table 2).

**Table 2** Correlation Analysis Between RDW and Related Clinical Parameters

Characteristic	r	P value
Age (years)	-0.100	0.309
CRP (mg/L)	0.277	0.004
White blood cell count ( $\times 10^9/L$ )	0.155	0.112
Neutrophil count ( $\times 10^9/L$ )	0.112	0.249
Platelet count ( $\times 10^9/L$ )	0.059	0.549
Lymphocyte count ( $\times 10^9/L$ )	-0.222	0.022
Hemoglobin (g/L)	-0.109	0.265
Red blood cell count ( $\times 10^{12}/L$ )	0.268	0.005
PLR	0.496	<0.001
NLR	0.319	0.001
Corrected calcium (mmol/L)	-0.140	0.150
Phosphate (mmol/L)	0.273	0.004
Parathyroid hormone (pg/mL)	-0.081	0.435
Albumin (g/L)	0.056	0.564

**Table 3** Multivariate Logistic Regression Analysis of Laboratory Parameters Between the Two Groups

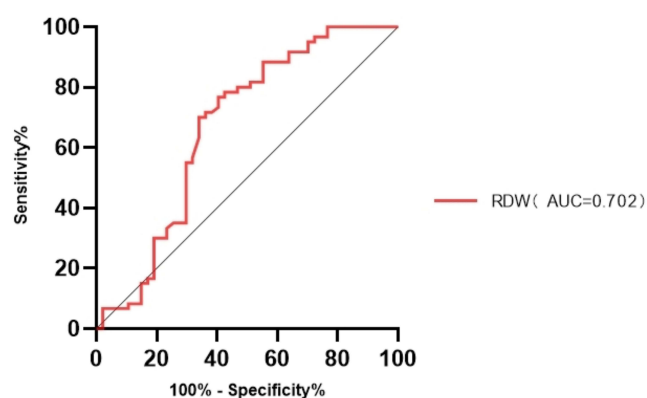
Variable	B	S.E.	Wals	P value	OR (95% CI)
RDW	0.573	0.265	4.678	0.031	1.774 (1.055,2.983)
Neutrophil count	0.053	0.046	1.334	0.248	1.054 (0.964, 1.153)
NLR	-0.600	0.598	1.005	0.316	0.549(0.170,1.773)
PLR	0.046	0.557	0.007	0.936	1.047 (0.351,3.120)
White blood cell	0.576	0.230	6.291	0.012	1.779(1.134,2.790)
CRP	0.168	0.322	0.272	0.602	1.183(0.629,2.222)
Constant	10.820	3.986	7.368	0.007	—

## Multivariate Logistic Regression Analysis

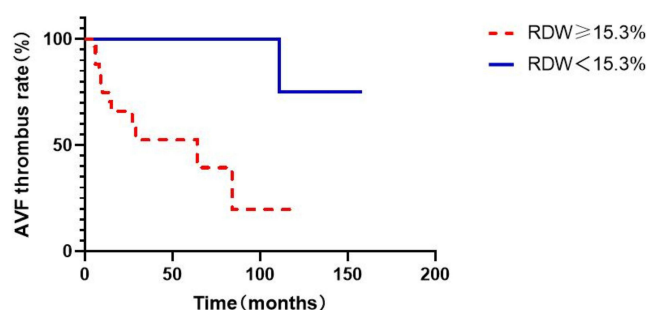
Multivariate logistic regression analysis was performed with AVF thrombosis as the dependent variable (absent = 0, present = 1). The model incorporated RDW, CRP, white blood cell count, neutrophil count, NLR, and PLR. RDW was identified as an independent risk factor for AVF thrombosis (OR = 1.774, 95% CI: 1.055–2.983,  $P < 0.05$ , Table 3).

## Predictive Value of RDW for Late AVF Thrombosis

The ROC curve was also drawn to intuitively represent the predictive value of RDW for Late Arteriovenous Fistula Thrombosis in Maintenance Hemodialysis Patients. The AUC under the curve was 0.702 (95% CI: 0.596–0.808,  $P < 0.001$ ). The optimal RDW cutoff value, determined by the Youden index, was 15.30%. At this threshold, sensitivity and specificity for predicting thrombosis were 60.00% and 98.30%, respectively (Figure 1). Kaplan-Meier analysis demonstrated that patients with  $RDW \geq 15.3\%$  had significantly shorter AVF survival times (Log rank test,  $P = 0.002$ , Figure 2).



**Figure 1** Receiver operating characteristic (ROC) curve of RDW for predicting late AVF thrombosis.



**Figure 2** Comparison of AVF survival time between patients with different RDW levels.

## Discussion

To the best of our knowledge, this is the first study investigating the prognostic value of RDW in Maintenance Hemodialysis Patients with Late Arteriovenous Fistula Thrombosis. Our results show that multivariate logistic regression analysis identified only RDW as an independent risk factor for late AVF thrombosis (OR = 1.774, 95% CI: 1.055–2.983,  $P < 0.05$ ). In contrast, other conventional inflammatory markers, including CRP, failed to demonstrate independent predictive value. The optimal RDW cutoff value for predicting late AVF thrombosis was determined to be 15.30%, with a specificity of 98.3%.

The microinflammatory state refers to a persistent, low-grade non-infectious inflammatory response characterized by chronic overexpression of various inflammatory cytokines, representing a concealed and sustained immune dysregulation.<sup>14</sup> It is clinically marked by elevated levels of inflammatory markers such as C-reactive protein (CRP), tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), and interleukin-6 (IL-6).<sup>4</sup> In addition to traditional risk factors including advanced age, diabetes, repeated cannulation, and hypercoagulability, recent studies suggest that microinflammation is also a key mechanism contributing to late AVF thrombosis in patients with chronic kidney disease.<sup>15</sup>

Red blood cell distribution width (RDW) is a parameter reflecting heterogeneity in erythrocyte volume. An elevated RDW indicates increased variability in red blood cell size, suggesting greater dispersion in volume distribution.<sup>16</sup> Microinflammation can disrupt erythropoiesis and impair erythrocyte deformability, leading to greater size variability and subsequent elevation in RDW. Existing evidence indicates that elevated RDW has predictive value for various thrombotic diseases, potentially mediated through its reflection of a pro-thrombotic microinflammatory state.<sup>17</sup> A study by Lippi et al involving 3845 participants demonstrated a positive correlation between RDW and CRP<sup>18</sup> -CRP levels in individuals with RDW  $\geq 14.8\%$  were approximately three times higher than those with RDW  $< 13.1\%$ —suggesting that RDW may serve as a sensitive indicator of chronic low-grade inflammation. Consistent with these findings, our study found significantly higher levels of RDW, white blood cell count, CRP, neutrophil count, NLR, and PLR in the thrombosis group. Pearson correlation analysis further revealed positive correlations between RDW and CRP, red blood cell count, PLR, and NLR, supporting the presence of a microinflammatory state in patients with late AVF thrombosis and indicating that RDW may contribute to thrombosis prediction by reflecting such inflammatory responses.

Our results demonstrated significantly elevated RDW in the thrombosis group. Multivariate logistic regression identified RDW as an independent risk factor for late AVF thrombosis, whereas CRP, white blood cell count, neutrophil count, NLR, and PLR did not exhibit independent predictive value. This suggests that RDW may be a more sensitive and earlier indicator of microinflammatory status compared to traditional markers, thereby offering superior predictive utility for late AVF thrombosis. Afsar et al<sup>19</sup> also reported RDW as an independent predictor of early AVF failure in patients with chronic kidney disease (OR = 1.449,  $P = 0.033$ ). Other previous studies<sup>20,21</sup> similarly support RDW as an independent risk factor for AVF thrombosis, which is consistent with our findings.

The optimal RDW cutoff value for predicting late AVF thrombosis, determined by the Youden index, was 15.30%. At this threshold, specificity reached 98.3%. To date, there are limited studies establishing RDW cutoff values for AVF thrombosis prediction. A previous prospective study<sup>[14]</sup> reported an area under the ROC curve of 0.644 (CI: 0.51–0.76;  $p = 0.046$ ) for RDW in predicting late AVF thrombosis, with RDW  $> 16.2\%$  associated with significantly reduced 24-month patency rates. The higher AUC (0.702) and relatively lower cutoff value observed in our study may be attributed to population differences and sample characteristics. Nonetheless, both studies support the role of RDW as a useful predictive marker with high specificity.

These findings have practical implications. RDW is a routine, low-cost, and readily available parameter from the complete blood count. Our results indicate that elevated RDW may help identify hemodialysis patients at higher risk for late AVF thrombosis. For clinicians, this suggests the value of closer fistula surveillance in patients with high RDW and prompt attention to potential inflammation or iron metabolism abnormalities. Utilizing such routine biomarkers offers a simple approach to individualize vascular access monitoring and improve long-term outcomes.

## Limitations

This study has several limitations. First, it was designed as a single-center retrospective analysis with a relatively small sample size, which may introduce selection and information bias. Second, although basic clinical and laboratory parameters were collected, the study did not account for several potential confounding factors that may influence AVF thrombosis, such as fistula location, vessel depth, cannulation frequency, or patient compliance. Third, this study could not dynamically monitor RDW changes, leaving the temporal variations and clinical relevance for risk prediction unassessed.

## Conclusion

This single-center retrospective study identified elevated red blood cell distribution width (RDW) as an independent risk factor for late arteriovenous fistula (AVF) thrombosis in maintenance hemodialysis patients. As a routine, low-cost, and reproducible hematological parameter, RDW may serve as a clinically useful marker to identify patients at higher risk for late AVF thrombosis. Early recognition of these individuals could enable closer surveillance and timely intervention, potentially improving access patency and patient outcomes. Due to the limitations of a single-center retrospective design with a relatively small sample size, larger multicenter prospective studies are warranted to validate these findings and establish optimal RDW-based intervention strategies.

## Disclosure

The authors report no conflicts of interest in this work.

## References

- Lok CE, Huber TS, Lee T, et al. KDOQI clinical practice guideline for vascular access: 2019 update. *Am J Kidney Dis.* 2020;75(4 Suppl 2):S1–S164. doi:10.1053/j.ajkd.2019.12.001
- Ding X, Chen J, Wu C, et al. Nucleotide-binding oligomerization domain-like receptor protein 3 deficiency in vascular smooth muscle cells prevents arteriovenous fistula failure despite chronic kidney disease. *J Am Heart Assoc.* 2019;8(1):e011211. doi:10.1161/JAHA.118.011211
- Murakami M, Fujii N, Kanda E, et al. Association of four types of vascular access including arterial superficialization with mortality in maintenance hemodialysis patients: a nationwide cohort study in Japan. *Am J Nephrol.* 2023;54(3–4):83–94. doi:10.1159/000529991
- Roşu CD, Bolintineanu SL, Căpăstraru BF, Iacob R, Stoicescu ER, Petrea CE. Risk factor analysis in vascular access complications for hemodialysis patients. *Diagnostics.* 2025;15(1):88. doi:10.3390/diagnostics15010088
- Al-Jaishi AA, Oliver MJ, Thomas SM, et al. Patency rates of the arteriovenous fistula for hemodialysis: a systematic review and meta-analysis. *Am J Kidney Dis.* 2014;63(3):464–478. doi:10.1053/j.ajkd.2013.08.023
- Zhang Y, Jiang H-L, Liu F, Xu Y-C, Du H-X. Factors influencing the presence of late thrombosis in autogenous arteriovenous fistulas in patients on maintenance haemodialysis. *Chinese J Blood Purif.* 2025;24(9):776–780. doi:10.3969/j.issn.1671-4091.2025.09.011
- Ying J, Cai G, Zhang Y, Zhu M, Pan M, Zhang P. Development and validation of a risk prediction model for autologous arteriovenous fistula thrombosis in patients receiving maintenance hemodialysis. *Ren Fail.* 2025;47(1):2477832. doi:10.1080/0886022X.2025.2477832
- Zhan Y, Fu X, Bi W, Li G. Risk factors for venous thromboembolism in patients with chronic kidney disease: a systematic review and meta-analysis. *Ren Fail.* 2024;46(2):2431149. doi:10.1080/0886022X.2024.2431149
- Bucciarelli P, Maino A, Felicetta I, et al. Association between red cell distribution width and risk of venous thromboembolism. *Thromb Res.* 2015;136(3):590–594. doi:10.1016/j.thromres.2015.07.020
- Lippi G, Cervellin G, Sanchis-Gomar F. Red blood cell distribution width: a marker of anisocytosis potentially associated with atrial fibrillation. *World J Cardiol.* 2019;11(12):292–304. doi:10.4330/wjc.v11.i12.292
- Wang Z, Korantzopoulos P, Roeber L, Liu T. Red blood cell distribution width and atrial fibrillation. *Biomarker Med.* 2020;14(13):1289–1298. doi:10.2217/bmm-2020-0041
- Gersh KC, Nagaswami C, Weisel JW. Fibrin network structure and clot mechanical properties are altered by incorporation of erythrocytes. *Thromb Haemost.* 2009;102(6):1169–1175. doi:10.1160/TH09-03-0199
- Yu FT, Armstrong JK, Tripette J, Meiselman HJ, Cloutier G. A local increase in red blood cell aggregation can trigger deep vein thrombosis: evidence based on quantitative cellular ultrasound imaging. *J Thromb Haemost.* 2011;9(3):481–488. doi:10.1111/j.1538-7836.2010.04164.x
- Tang Y, Purkayastha S, Cai D. Hypothalamic microinflammation: a common basis of metabolic syndrome and aging. *Trends Neurosci.* 2015;38(1):36–44. doi:10.1016/j.tins.2014.10.002
- Oh DJ, Lee JH, Kwon YE, Choi HM. Relationship between arteriovenous fistula stenosis and circulating levels of neutrophil granule proteins in chronic hemodialysis patients. *Ann Vasc Surg.* 2021;77:226–235. doi:10.1016/j.avsg.2021.05.056
- Lee SY, Wong LT, Chao WC. The association between week-one red blood cell distribution width and one-year survival in critically ill patients: propensity score-based multicenter analysis. *Eur J Med Res.* 2025;30(1):551. doi:10.1186/s40001-025-02839-2
- Alcaino H, Pozo J, Pavez M, Toledo H. [Red cell distribution width as a risk marker in patients with cardiovascular diseases]. *Rev Med Chil.* 2016;144(5):634–642. doi:10.4067/S0034-98872016000500012
- Ercan M, Konukoğlu D, Erdem T, Onen S. The effects of cholesterol levels on hemorheological parameters in diabetic patients. *Clin Hemorheol Microcirc.* 2002;26(4):257–263.

19. Afsar B. The impact of inflammatory factors associated with primary arteriovenous failure. *Int J Artif Organs*. 2013;36(10):710–716. doi:10.5301/ijao.5000235
20. Bojakowski K, Dzabic M, Kurzejamska E, et al. A high red blood cell distribution width predicts failure of arteriovenous fistula. *PLoS One*. 2012;7(5):e36482. doi:10.1371/journal.pone.0036482
21. Usman R, Jamil M, Naveed M. High preoperative neutrophil-lymphocyte ratio (NLR) and red blood cell distribution width (RDW) as independent predictors of native arteriovenous fistula failure. *Ann Vasc Dis*. 2017;10(3):205–210. doi:10.3400/avd.17-00016

**International Journal of General Medicine**

**Publish your work in this journal**

The International Journal of General Medicine is an international, peer-reviewed open-access journal that focuses on general and internal medicine, pathogenesis, epidemiology, diagnosis, monitoring and treatment protocols. The journal is characterized by the rapid reporting of reviews, original research and clinical studies across all disease areas. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-general-medicine-journal>

**Dovepress**

Taylor & Francis Group