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RESEARCH ARTICLE

# Red Blood Cell Distribution Width in Cats with Chronic Kidney Disease: A Retrospective Study

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**Abstract**

Chronic kidney disease (CKD) is one of the commonly observed progressive diseases in cats. Red blood cell distribution width (RDW) is a parameter that reflects variability in erythrocyte size. Recently, RDW has been shown to have potential value as a biomarker for disease severity and progression in various conditions in both human and veterinary medicine; however, information regarding its clinical significance in feline CKD remains limited. The aim of this study was to compare RDW values among cats with CKD, acute-on-chronic kidney disease, and healthy cats and to evaluate the relationship between RDW and hematological and biochemical parameters. In this study, cats with CKD, AOC, and healthy cats presented to our clinic between 2022 and 2025 were retrospectively evaluated. Cats with any concurrent endocrine, neoplastic, or infectious diseases were excluded from the study. Cats with CKD were divided into three groups: early-stage kidney disease (IRIS stages 1 and 2), advanced-stage kidney disease (IRIS stages 3 and 4), and acute on chronic kidney disease (AOC). Hematological, biochemical, and ultrasonographic findings were evaluated. One-way analysis of variance (ANOVA) and Pearson correlation analysis were performed. No significant relationships were detected between RDW and SDMA, UPC, BUN, or phosphorus (PHOS) among the study groups. Only a borderline negative correlation was identified between RDW and serum creatinine concentration (r=−0.216; P=0.050). In conclusion, although RDW may be used in other diseases or in human medicine, it does not appear to be a reliable marker for determining disease progression in feline CKD.

**Keywords:** Cat, Chronic kidney disease, Acute-on-chronic kidney disease, RDW

## Introduction

Chronic kidney disease (CKD) is one of the most common diseases in cats. CKD is defined as the presence of structural and functional abnormalities in one or both kidneys persisting for more than three months. The International Renal Interest Society (IRIS) has established classification criteria based on creatinine and SDMA values in stable kidney patients. These classification criteria are used both therapeutically and prognostically [1]. CKD can be observed at any age; however, its prevalence is generally higher in older cats compared to younger ones. A previous study reported that approximately 63% of cats with kidney disease were over 10 years of age, while 37% were under 10 years of age [2]. CKD is a progressive disorder characterized by ongoing nephron loss over time [3]. Proteinuria, anemia, hypertension, hyperphosphatemia, and acute on chronic kidney disease (AOC) are considered to be associated with the progression of chronic kidney damage [4].

Acute on chronic kidney disease (AOC) can be defined as an episodic decrease in glomerular filtration rate (GFR) resulting from renal injury (prerenal, renal, or postrenal) in a cat with pre-existing chronic kidney damage. It is frequently characterized by acute renal parenchymal injury and a decline in renal function. The prognosis of acute kidney injury is influenced by multiple factors, including etiology, severity of injury, availability of treatment options (e.g., hemodialysis), and owner compliance [5].

An increase in red blood cell distribution width (RDW), expressed as a percentage, is a common indicator of heterogeneity in red blood cell (RBC) size and is reported as part of a complete blood count. RDW is calculated by dividing the standard deviation of mean cell volume by the mean corpuscular volume (MCV) [6,7]. An increase in RDW generally occurs due to a decrease in MCV or an increase in RBC size [8].

The association between high RDW and renal impairment

is multifactorial. According to studies in human cohorts, chronic inflammation suppresses erythropoiesis, while oxidative stress leads to premature erythrocyte destruction [9-11]. Furthermore, inflammation induced hepcidin elevation in CKD patients disrupts iron metabolism, a process that inherently increases RDW values [12].

Recently, increased RDW has been used as a prognostic factor [13,14]. One study demonstrated that an increased RDW value was associated with higher mortality in hospitalized dogs [15]. Another study conducted in humans showed that increased RDW was independently associated with the progression of CKD. These findings suggest that RDW has prognostic value and may be an indicator of CKD progression [16].

The aim of this study was to compare RDW values among cats with CKD, acute on chronic kidney disease, and healthy controls and to evaluate the relationship between RDW and hematological and biochemical parameters.

We hypothesized that RDW values would be higher in cats with CKD and acute on chronic kidney disease and that RDW would be associated with selected hematological and biochemical parameters.

## Material and Methods

### Ethical Statement

The Afyon Kocatepe University Local Ethics Committee for Animal Experiments determined that ethical committee approval was not required, as this was a retrospective study. (Approval no: 49533702/354).

A total of 95 medical records of cats presented to the clinic between 2022 and 2025 were screened for eligibility. Following application of the predefined exclusion criteria, 12 cats were excluded from the study, including 7 with heart disease, 4 with infectious disease, and 1 that had received a blood transfusion within the previous three months. Ultimately, 83 cats were included in the final analysis: 12 healthy controls, 20 cats with early stage CKD (IRIS stages 1-2), 24 cats with advanced stage CKD (IRIS stages 3-4), and 27 cats with acute on chronic kidney disease (AOC).

For inclusion of cats with CKD, CKD diagnosis was established based on persistent azotemia (elevated serum creatinine concentration for at least three months) together with clinical and laboratory findings compatible with chronic kidney disease. These included decreased urine specific gravity (USG <1.035), increased SDMA concentration, and/or characteristic ultrasonographic changes such as increased renal cortical echogenicity and loss of corticomedullary differentiation. CKD staging was performed according to IRIS guidelines based primarily on serum creatinine concentrations obtained from clinically stable patients [17]. Urinalysis and ultrasonographic examination were performed as part of the diagnostic process in included cats. Cats with a positive urine culture, urinary tract obstruction, liver disease, heart disease, or infectious disease within the previous month were excluded from the study.

For the acute on chronic kidney disease (AOC) group, cats were considered eligible if they exhibited clinical signs consistent with acute kidney injury (anorexia, lethargy, vomiting), a >20% increase in creatinine concentration compared to previously classified values according to IRIS criteria, the presence of certain urinalysis markers (glycosuria with normoglycemia, cylindruria), and more than two characteristic findings on abdominal ultrasonography, such as increased renal cortical echogenicity and loss of corticomedullary differentiation [18].

Because RDW may be affected by concurrent conditions, cats with simultaneous systemic or endocrine diseases, neoplasia, or infectious diseases were excluded. Additionally, cats that had received a blood transfusion within the previous three months, had blood loss due to trauma, or had undergone recent surgical intervention were excluded from the study. These conditions were diagnosed through physical examination and laboratory and radiological methods [19].

Cats with CKD were divided into three groups: early stage kidney disease (IRIS stages 1 and 2), advanced stage kidney disease (IRIS stages 3 and 4), and acute on chronic kidney disease (AOC). For the control group, 12 healthy cats that presented for annual check-ups or had blood samples collected prior to neutering procedures were included. Hematological and biochemical analyses, urinalysis, and ultrasonographic evaluations were performed. Cats included in the control group were assessed for health parameters and confirmed to be within reference ranges, and only cats without evidence of infection were selected.

Hematological analysis results (complete blood count with leukocyte differential), biochemical profiles (serum urea, creatinine, total protein, albumin, total calcium, total phosphorus, alanine aminotransferase and alkaline phosphatase activities), and urinalysis results (dipstick analysis, microscopic examination of urinary sediment, urine specific gravity [USG], and urine protein to creatinine ratio [UPC]) were evaluated. However, only red blood cell count (RBC), hemoglobin concentration (HGB), hematocrit (HCT), urea, creatinine, USG, and UPC were reported and included in the statistical analysis for this study.

Blood parameters of cats in the CKD and control groups were measured using a hematology analyzer (IDEXX

ProCyte Dx), a biochemical analyzer and urine protein/creatinine ratio (UPC) using a biochemical analyzer (IDEXX Catalyst ONE), and urinalysis using a urine analyzer (IDEXX UA). Ultrasonographic examinations were performed using an ultrasound device (Philips Affiniti 70).

### Statistical Analysis

Statistical analyses of the data obtained in this study were performed using IBM SPSS Statistics 26.0 software. Descriptive statistics included frequency (n) and percentage (%) for qualitative variables, and mean, standard deviation, minimum, and maximum values for quantitative variables. Data distribution was assessed using the Shapiro-Wilk test and homogeneity of variance was evaluated using Levene's test. Since the data followed a normal distribution, parametric tests (One-Way ANOVA and Pearson correlation) were employed. One-way analysis of variance (One-Way ANOVA) was used to evaluate differences among the groups (Control, AOC, IRIS 1-2, and IRIS 3-4). For variables showing statistically significant differences in ANOVA, the Duncan post hoc test was applied to determine intergroup differences. In addition, Pearson correlation analysis was performed to assess relationships between certain hematological and biochemical variables and SDMA, RDW, and creatinine levels. A P-value <0.05 was considered statistically significant in all analyses. Because this was a retrospective study, the sample size was determined by the number of eligible cases available in the medical records during the study period. Therefore, a priori sample size calculation was not performed.

## Results

Demographic characteristics of cats, including sex distribution, age, and body weight, are summarized in *Table 1*.

No statistically significant differences were detected in RDW values among the study groups (P>0.05). When hematological and biochemical parameters evaluated among the control, AOC, IRIS 1-2, and IRIS 3-4 groups were examined, statistically significant differences were detected in HCT (%), LYM (%), MONO (%), MONO (K/uL), SDMA, creatinine (CREA), BUN, BUN/CREA ratio, phosphorus (PHOS), and UPC values (P<0.05). Significant differences were observed for HCT, LYM, MONO, SDMA, creatinine, BUN, phosphorus, and UPC values among the groups (P<0.05) *(Table 2)*. In contrast, no statistically significant differences were found for RBC, HGB, MCV, MCH, MCHC, RDW, RETIC, WBC, Neu, EOS, BAS, PLT, MPV, PDW, or PCT parameters (P>0.05). All results are presented in *Table 2*.

***Table 1.*** *Distribution of sex, age and weight according to control, aoc and IRIS stages*

| Variable | | Groups | | | |
|---|---|---|---|---|---|
| Control | | AOC | IRIS 1- 2 | IRIS 3- 4 | |
| Sex | Female | 6 (50.0) | 15 (55.6) | 14 (70.0) | 15 (62.5) |
| | Male | 6(50.0) | 12 (44.4) | 6 (30.0) | 9 (37.5) |
| Age (Year) | | 5.67±4.81 (1-15) | 10.37±2.86 (5-16) | 10.05±4.18 (3-18) | 11.75±2.86 (6-16) |
| Weight (kg) | | 4.27±0.56 (3.5-5.2) | 4.26±0.94 (2.65-6.1) | 3.89±0.7 (2.35-5.5) | 3.83±0.7 (2.5-5.5) |

*AOC: Acute on chronic kidney disease; IRIS: International renal interest society*

According to correlation analysis, relationships between RDW values and hematological and biochemical parameters were evaluated. The analysis revealed a significant positive correlation only between RDW and red blood cell count (RBC) (R=0.439; P=0.000), indicating that increases in RDW were associated with increases in RBC count. A weak and borderline negative correlation was observed between RDW and creatinine (CREA) (R=−0.216; P=0.050), suggesting a slight tendency for creatinine levels to decrease as RDW increased; however, this relationship should be interpreted cautiously due to its borderline statistical significance. No significant correlations were found between RDW and SDMA, HCT, HGB, BUN, PHOS, or urine protein/creatinine ratio (UPC) (P>0.05). All data and results of the correlation analysis are presented in *Table 3*.

## Discussion

In this retrospective study, RDW values were evaluated in cats diagnosed with chronic kidney disease at different stages and acute on chronic kidney disease and compared with healthy cats. RDW values did not show a statistically significant difference among the groups. RDW was found to have a positive correlation with erythrocyte count and a weak, borderline significant negative correlation with creatinine. However, RDW primarily reflects variability in erythrocyte size rather than erythrocyte number. Therefore, the biological significance of this correlation remains unclear and should be interpreted cautiously. Additionally, the weak negative correlation detected between RDW and creatinine indicates that RDW is not directly associated with loss of renal function but is more influenced by hematological changes.

In the veterinary literature, RDW has been suggested to have prognostic importance in feline cardiovascular diseases, such as hypertrophic cardiomyopathy [19]. Similar findings have been reported in human studies, where RDW showed a negative correlation with glomerular filtration rate and a positive association with serum creatinine levels [20]. Although a statistically significant correlation was observed, its strength was weak and may

***Table 2.*** *Comparative descriptive statistics of hematological and biochemical parameters according to control. Aoc and IRIS stages*

| Parameters | Groups | | | | F | P |
|---|---|---|---|---|---|---|
| | Control | AOC | IRIS 1- 2 | IRIS 3- 4 | | |
| RDW% | 24.53±1.91 (21.8-27.3) | 24.61±4.46 (19.1-36.1) | 26.29±5.34 (18.9-35.4) | 24.46±6.34 (19.1-47.1) | 0.606 | 0.613 |
| RBC M/uL | 9.68±1.24 (7.12-11.48) | 8.71±1.5 (6.29-11.69) | 8.8±1.79 (4.91-11.39) | 8.31±1.81 (5.54-13.73) | 1.860 | 0.143 |
| HCT% | 43.05±6.09a (29.6-53.1) | 36.21±7.7b (26.9-56) | 38.35±7.44ab (23.9-51.7) | 34.87±7.08b (23.3-46.5) | 3.757 | 0.014* |
| HGB g/dL | 14.02±1.79 (10-16.3) | 11.75±1.82 (9.3-15.3) | 12.17±2.18 (7.7-16.4) | 15.68±19.59 (8-107) | 0.677 | 0.569 |
| MCV fL | 44.54±3.54 (38.4-49.6) | 41.78±6.00 (31.4-54.6) | 44.19±6.58 (33-56.2) | 42.24±4.83 (32.7-52.2) | 1.193 | 0.318 |
| MCH pg | 14.50±1.04 (12.9-16.4) | 13.66±1.91 (10.1-19.8) | 14.02±1.82 (11.7-19.6) | 14.19±1.98 (10.7-19.8) | 0.709 | 0.550 |
| MCHC pg/dL | 32.63±1.39 (30.7-34.3) | 31.68±4.73 (14-37.9) | 31.94±2.81 (27.4-37.5) | 33.38±2.67 (28-38.5) | 1.202 | 0.315 |
| RETIC% | 0.30±0.17 (0.1- 0.7) | 0.60±0.39 (0.1-1.3) | 0.39±0.24 (0.1-1) | 0.48±0.41 (0-1.5) | 2.584 | 0.059 |
| RETIC K/uL | 28.63±15.86 (5.8-66.5) | 46.02±35.85 (5.7-113) | 33.95±22.35 (7.2-82.7) | 38.78±34.42 (4-121.4) | 1.124 | 0.345 |
| WBC | 8.58±2.95 (3.52-12.79) | 17.62±14.78 (4.04-63.8) | 11.03±4.91 (4.56-26.35) | 11.11±13.26 (2.66-70.6) | 2.493 | 0.066 |
| Neu% | 49.83±11.1 (32.8-66.4) | 57.79±19.15 (21.2-89.3) | 61.8±18.22 (23.7-83.6) | 56.78±18.57 (16.8-87.6) | 1.139 | 0.338 |
| Lym% | 38.29±11.44a (22.3-57.9) | 22.06±13.51b (4.8-45.7) | 26.95±15.92b (4.8-65) | 25.78±15.6b (4.8-60.1) | 3.514 | 0.019* |
| Mono% | 2.78±0.88b (1.5-4.2) | 6.53±2.95a (2.1-16.2) | 4.83±2.56a (2.1-13.1) | 5.74±2.61a (1.9-13.4) | 6.435 | 0.001* |
| EOS% | 8.04±3.73 (2.4-15.8) | 6.46±6.1 (0.4-29.7) | 5.76±4.41 (0.9-19.3) | 5.97±3.72 (0.4-13.7) | 0.656 | 0.582 |
| BAS% | 1.06±0.71 (0.3-2.7) | 0.98±1.24 (0.1-4.6) | 0.58±0.29 (0.01-1.1) | 1.20±1.97 (0.3-9.91) | 0.856 | 0.467 |
| Neu K/uL | 4.15±1.31 (1.4-6.91) | 12.86±20.28 (1.52-106) | 6.74±3.69 ( 2.06-14) | 5.2±3.54 (1.33-12.89) | 2.418 | 0.072 |
| Lym K/uL | 3.44±2 (1.38-7.41) | 2.72±2 (0.32-7.29) | 2.74±1.97 (0.71-9.38) | 2.1±1.36 (0.32-4.77) | 1.507 | 0.219 |
| Mono K/uL | 0.25±0.13c (0.07-0.51) | 0.89±0.63a (0.13-2.33) | 0.57±0.44b (0.15-2.03) | 0.51±0.3bc (0.14-1.41) | 6.477 | 0.001* |
| EOS K/uL | 0.64±0.3 (0.27-1.26) | 0.67±0.53 (0.03-2.07) | 0.56±0.39 (0.09-1.8) | 0.43±0.26 (0.03-1.05) | 1.615 | 0.193 |
| BAS K/uL | 0.09±0.07 (0.02-0.23) | 0.06±0.05 (0.01-0.16) | 0.06±0.03 (0.01-0.1) | 0.06±0.03 (0.01-0.11) | 2.142 | 0.102 |
| PLT K/uL | 246.58±97.77 (72-411) | 298.78±132.59 (112-561) | 282.95±117.19 (106-515) | 315.04±91.94 (171-488) | 1.045 | 0.378 |
| SDMA | 10.00±1.81c (7-13) | 41.00±18.84a (18-82) | 19.90±5.96b (14-41) | 34.38±11.6a (25-67) | 21.314 | 0.000* |
| CREA | 1.20±0.2d (0.8-1.5) | 8.96±2.24a (5.8-13.6) | 4.68±2.7c (1.4-8.8) | 6.94±1.34b (2.9-9.8) | 47.864 | 0.000* |
| BUN | 23.00±5.03d (15-32) | 126.11±19.99a (81-175) | 65.95±30.08c (21-114) | 88.50±18.94b (44-125) | 72.384 | 0.000* |
| BUN/CREA Ratio | 19.58±5.85a (11-30) | 14.97±3.28b (9.26-24) | 15.33±4.17b (10-25) | 13.08±2.80b (8-19) | 7.686 | 0.000* |
| PHOS | 4.48±0.51c (3.4-5.4) | 11.47±3.47a (4.5-20) | 7.50±2.74b (2.8-12) | 7.51±2.41b (3.4-12) | 21.096 | 0.000* |

* P<0.05; *Different superscript letters (a, b, c) within a row indicate statistically significant differences between groups according to duncan post hoc test (P<0.05). RDW: Red blood cell distribution width; RBC: Red blood cell count; HCT: Hematocrit; HGB: Hemoglobin; MCV: Mean corpuscular volume; MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration; RETIC: Reticulocyte; WBC: White blood cell; Neu: Neutrophil; Lym: Lymphocyte; Mono: Monocyte; EOS: Eosinophil; BAS: Basophil; PLT: Platelet count; SDMA: Symmetric dimethylarginine; CREA: Creatinine; BUN: Blood urea nitrogen; BUN/CREA ratio: Blood urea nitrogen to creatinine ratio; PHOS: Phosphorus*

*Table 3. Correlation analysis between rdw values and hematological and biochemical parameters*

| Parameters | | RDW% |
|---|---|---|
| SDMA | R | 0.020 |
| | P | 0.855 |
| CREA | R | -0.216 |
| | P | 0.050 |
| RBC M/uL | R | 0.439 |
| | P | 0.000* |
| HCT% | R | 0.069 |
| | P | 0.537 |
| HGB g/dL | R | -0.038 |
| | P | 0.733 |
| BUN | R | -0.096 |
| | P | 0.390 |
| PHOS | R | -0.097 |
| | P | 0.382 |
| UPC | R | -0.062 |
| | P | 0.608 |

** P<0.05; R: Correlation coefficient; SDMA: Symmetric dimethylarginine; CREA: Creatinine; RBC: Red blood cell count; HCT: Hematocrit; HGB: Hemoglobin; BUN: Blood urea nitrogen; PHOS: Phosphorus; UPC: Urine protein/creatinine ratio*

not have strong clinical relevance. However, in the present study, RDW did not demonstrate similar value in the context of CKD and AOC. Therefore, RDW may exhibit different prognostic behavior across different disease groups in cats. RDW alone does not appear to be a reliable or clinically useful indicator for identifying the presence or progression of CKD or AOC in cats.

In chronic kidney disease, inflammation, decreased erythropoietin production, bone marrow dysfunction due to uremic toxins, and disturbances in iron metabolism can significantly affect red blood cell distribution width [21]. Studies conducted in human and veterinary medicine have shown that increased RDW values may be associated with mortality, inflammation, and prognosis of chronic diseases [6,15,16,19,22]. Although RDW has been shown to be prognostically associated with many chronic diseases in the literature, it remains unclear whether RDW increases with CKD progression in cats. Therefore, this study was designed to investigate the relationship between RDW and CKD and to determine whether RDW could be used as a parameter to predict disease progression.

The main reasons for differences among study results may include interspecies hematological differences, the fact that normocytic normochromic anemia is commonly observed in cats with CKD, and that RDW yields more meaningful results particularly in conditions where erythrocyte morphology changes markedly, such as regenerative anemia [22].

Limitations of this study include the relatively small sample size, the retrospective nature of data collection, potential differences in age distribution between groups, and the lack of inclusion of inflammatory markers that may influence RDW values. The heterogeneity between CKD and AOC groups may have influenced the variability of RDW values. Future studies with larger populations and prospective designs may be useful in elucidating the true prognostic significance of RDW in CKD and AOC.

In conclusion, RDW values did not differ significantly among cats with chronic kidney disease, acute on chronic kidney disease, and healthy controls. Furthermore, RDW showed no clinically relevant associations with most hematological and biochemical parameters, except for a weak and borderline negative correlation with creatinine concentration. These findings suggest that RDW is not a reliable biomarker for assessing disease progression in feline renal disease. The discrepancy between the present results and previous studies conducted in humans may be attributed to species specific differences in erythrocyte physiology. Future prospective studies with larger sample sizes and inclusion of inflammatory markers are warranted to better elucidate the potential role of RDW in feline renal diseases.

## Declarations

**Availability of Data and Materials:** The datasets generated and/or analyzed during this study are available from the corresponding author (ŞA) upon reasonable request.

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**Competing Interests:** The authors declare that they have no competing interests.

**Declaration of Generative Artificial Intelligence (AI):** The authors declare that no generative artificial intelligence tools were used to generate the scientific content of this manuscript. AI-assisted technologies were used only for language editing and readability improvement.

**Author Contributions:** SA: Study design, data collection, drafting of the manuscript. MK: Statistical analysis, interpretation of data, critical revision of the manuscript.

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