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Original Article

Utilization of Red Blood Cell Distribution Width in Predicting Length of Stay in Patients Treated in Cardiovascular Intensive Care Unit: A Cohort Study

K. S. K. Suratna[1], R. Dylan[1], C. Sunur[1], Jeffry[1], B. Oeiyano[1], F. M. Yofrido[1], D. U. Djafar[1], M. Luntungan[1]

Abstract

Background: The risk stratification of mortality in critically ill patients with heart disease has long been available and validated. Red Blood Cell Distribution Width (RDW) has traditionally been used in the differential diagnosis of anemias. High RDW is associated with worse outcomes in diverse scenarios, including in critical illness. This study aimed to investigate the correlation of RDW value with the length of Cardiovascular Intensive Care Unit (CICU) stay.

Methods: This cohort study was conducted at Prof. Dr. R. D. Kandou Hospital in Manado from February to May 2021. The study subjects were patients treated in the CICU. Statistical analysis was performed using Spearman's correlation and linear regression.

Results: Among 97 patients studied, the median Red Cell Distribution Width – Coefficient of Variation (RDW-CV) was 13.6% (Interquartile Range [IQR] 12.7-15.3), and the median CICU length of stay was 2.0 days (IQR 2.0-4.5). RDW demonstrated a significant positive correlation with CICU length of stay (Spearman's $\rho = 0.317$, $p = 0.002$). Linear regression analysis revealed that each 1% increase in RDW was associated with a 0.213-day rise in length of stay ($B = 0.213$, $\beta = 0.244$, $R^2 = 0.059$, $p = 0.016$).

Conclusions: Higher RDW values are significantly associated with longer CICU stay. As an easily accessible parameter, RDW shows promise as a useful prognostic marker for risk stratification in cardiac critical care.

[1]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Sam Ratulangi, Prof. Dr. R. D. Kandou Hospital, Manado, Indonesia.

Correspondence:
K. S. K. Suratna,

Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Sam Ratulangi, Prof. Dr. R. D. Kandou Hospital, Manado, Indonesia.

Email: sat.su15@yahoo.co.id

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Introduction

Cardiovascular Disease (CVD) remains the leading cause of disease burden worldwide and was responsible for 6.2 million deaths between the ages of 30 and 70 in 2019.[1] The incidence of CVD is increasing globally and includes several specific conditions, including Heart Failure (HF), Ischemic Heart Disease (IHD), hypertensive heart disease, peripheral vascular disease, and Atrial Fibrillation (AF).[2]

The Red Cell Distribution Width (RDW) is a simple, rapid, and readily available hematological parameter that measures the heterogeneity of red blood cell size and is now automatically generated by all commercially available hematological analyzers along with a Complete Blood Cell Count (CBC).[3] Clinical studies in CVD patients have reported that RDW is a novel independent predictor of all-cause mortality and Major Adverse Cardiac Events (MACE).[4-6] The association between RDW and CVD may involve several mechanisms, including inflammation, nutritional disturbances, and alteration in erythropoiesis.[7]

This study aimed to investigate the correlation between RDW value and Length of Stay (LOS) in the Cardiovascular Intensive Care Unit (CICU).

Methods

This was an analytical observational study with a cohort design. The study was conducted at Prof. Dr. R. D. Kandou Hospital in Manado from February to May 2021. Subjects included all patients treated in the CICU during this period. Patient data were obtained from medical records. Statistical analyses were performed using Spearman's rank correlation and linear regression.

Results

This study analyzed 97 CICU patients with distinct clinical profiles. As detailed in Table 1, the cohort had a mean age of 55.7 years and was predominantly male (71.1%). Acute coronary syndrome was the most common primary diagnosis (60.8%), while hypertension was the most prevalent preexisting condition (58.8%).

RDW demonstrated a significant positive correlation with CICU LOS (Spearman's $\rho = 0.317$, $p = 0.002$), as shown in both Figure 1 and Table 2. Linear regression analysis further indicated that each 1% increase in RDW was associated with a 0.213-day rise in LOS ($B = 0.213$, $\beta = 0.244$, $R^2 = 0.059$, $p = 0.016$).

Table 1. The demographic and clinical characteristics of study subjects (n=97).

Variables	Value (n=97)
Sex	
Men, n (%)	69 (71)
Women, n (%)	28 (29)
Age (years)	55.7 ± 14.1
BMI (kg/m2)	24.2 (22.2 – 26.1)
Smoking, n (%)	43 (44)
Primary Diagnosis at Presentation	
Acute Coronary Syndrome, n (%)	59 (60.8)
Acute Heart Failure, n (%)	16 (16.5)
Shock and Cardiac Arrest, n (%)	1 (1.0)
Arrhythmia and other, n (%)	17 (17.5)
Controlled Comorbidities, n (%)	4 (4.1)
Preexisting Conditions	
Hypertension, n (%)	57 (58.8)
Diabetes mellitus, n (%)	25 (25.8)
Chronic kidney disease, n (%)	21 (21.6)
Dyslipidemia, n (%)	15 (15.5)
Laboratory Parameters	
RDW-CV (%)	13.6 (12.7 – 15.3)
Outcome	
CICU length of stay (days)	2.0 (2.0 – 4.5)

Note: Data are presented as n(%), mean ± standard deviation, or median (IQR); BMI: Body Mass Index; RDW-CV: Red Blood Cell Distribution Width – Coefficient of Variation; CICU: Cardiovascular Intensive Care Unit.

Table 2. Spearman Correlation between RDW value (%) and length of CIC stay (days).

Variable	Correlation Coefficient (r)	n	p-Value
RDW value vs CICU length of stay	0.317	97	0.002*

*Significant (p<0.00); RDW: Red Cell Dsitribution Width, CICU: Cardiovascular Intensive Care Unit.

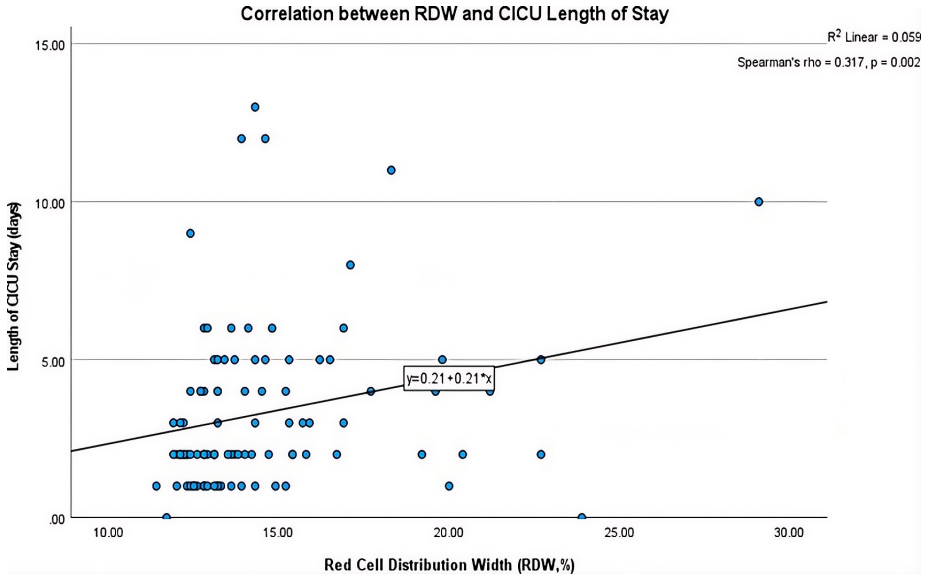

Figure 1. Scatter plot demonstrating the correlation between Red Cell Distribution Width (RDW) and the length of stay in the Cardiovascular Intensive Care Unit (CICU). The solid line represents the line of best fit from linear regression analysis ($R^2 = 0.059$). The correlation was statistically significant (Spearman's ρ (rho) = 0.317, p = 0.002).

As presented in Table 3, significant variations in LOS were observed across diagnostic categories (Kruskal-Wallis, p = 0.011). Acute Heart Failure (AHF) patients had the longest stays (5.06 ± 2.69 days), followed by acute coronary syndrome (3.02 ± 2.71 days), arrhythmia (2.76 ± 1.64 days), and controlled comorbidities (2.50 ± 2.63 days). Among preexisting conditions, non-hypertensive patients had significantly longer stays than hypertensive patients (4.05 ± 2.70 vs. 2.79 ± 2.48 days, p = 0.019). No other comorbidities were significantly associated with LOS.

Subgroup analysis based on primary diagnosis revealed that the correlation between RDW and CICU LOS was strongest in patients with acute coronary syndrome (ρ = 0.275, p = 0.035), as shown in Table 4. A similar but non-significant trend was observed in patients with AHF (ρ = 0.295, p = 0.268), likely due to the limited sample size. No meaningful correlation was found in arrhythmia patients (ρ = 0.006, p = 0.983).

Discussion

This study demonstrates a significant positive correlation between RDW and CICU LOS (Spearman's ρ = 0.317, p = 0.002), with each 1% increase in RDW associated with a 0.213-day increase in hospitalization duration. This finding aligns with Havens *et al.*[6] who demonstrated that RDW predicts outcomes in critically ill emergency patients. General surgery patients and Meynaar *et al.*[7] who established RDW as a mortality predictor in critically ill populations.

The significant variation in LOS across diagnostic categories underscores the importance of initial clinical presentation in determining healthcare resource utilization.[8] AHF patients had the longest stays (5.06 days), consistent with the

Table 3. Association between diagnosis categories, preexisting conditions, and CICU length of stay.

Variable	n	Mean LOS ± SD (days)	P-value
Primary Diagnosis Category			0.011
Acute Coronary Syndrome	59	3.02±2.71	
Acute Heart Failure	16	5.06±2.69	
Shock and Cardiac Arrest	1	5.00	
Arrhythmia and other	17	2.76±1.64	
Controlled Comorbidities	4	2.50±2.63	
Preexisting Conditions			
Hypertension			0.019
No	40	4.05±2.70	
Yes	57	2.79±2.48	
Diabetes Mellitus			0.981
No	72	3.31±2.41	
Yes	25	3.32±3.24	
Chronic Kidney Disease			0.675
No	76	3.25±2.64	
Yes	21	3.52±2.64	
Dyslipidemia			0.644
No	82	3.26±2,45	
Yes	15	3.60±3.54	

Note: SD, standard deviation; LOS, Length of stay.

Table 4. Correlation between RDW and CICU length of stay by primary diagnosis.

Primary Diagnosis	n	Spearman's ρ	P-value
Acute Coronary Syndrome	59	0.275	0.035
Acute Heart Failure	16	0.295	0.268
Arrhythmia and other	17	0.006	0.983

complex management challenges described in HF populations by Jung *et al.* and Felker et *al.*[8-9]

The pathophysiological basis for RDW's association with prolonged hospitalization involves several interconnected mechanisms. Elevated RDW reflects impaired erythropoiesis due to chronic inflammation and nutritional deficiencies, as explained by Weiss and Goodnough in anemia of chronic disease.[10] Our findings corroborate Allen *et al.*, who validated RDW's prognostic mechanisms in HF.[11] In acute coronary syndrome, the inflammatory cascade promotes endothelial dysfunction while suppressing erythrocyte maturation, consistent with chronic inflammation pathways in CVD described by Zyga and Kolovos.[5] This link between elevated RDW and worse outcomes in IHD is supported by Li *et al.* in coronary artery disease patients and Sahin *et al.* in non-ST elevation myocardial infarction.[12-13]

In HF, the relationship is more complex due to neurohormonal activation influencing the clinical course. Van Kimmenade *et al.* demonstrated RDW's association with 1-year mortality in AHF, further supporting our findings.[14]

The paradoxical finding that non-hypertensive patients had longer CICU stays than hypertensive patients (4.05 vs. 2.79 days, p = 0.019) may reflect more established treatment protocols in hypertensive patients or more acute decompensations in non-hypertensive patients requiring prolonged workup, consistent with patterns of risk adjustment in cardiovascular outcomes described by Krumholz *et al.*[15]

From a clinical perspective, RDW's accessibility and low cost make it valuable in resource-limited settings as a routinely available parameter.[3] The association between RDW and prolonged CICU stay suggests potential utility in triaging and risk stratification in cardiac critical care.

Study Limitations

This study has several limitations. First, the analysis focused on LOS without examining other clinical outcomes such as mortality or MACE. Second, the single-center design and sample size limit generalizability and statistical power for subgroup analyses. For instance, the small sample size in the AHF subgroup (n=16) likely contributed to the non-significant result despite a suggestive correlation. Finally, RDW was measured only at admission, preventing assessment of its dynamic changes during hospitalization. Despite these limitations, our findings provide valuable insights into RDW's prognostic utility in cardiac critical care.

Conclusion

This study establishes a significant positive correlation between RDW and the LOS in the CICU. Furthermore, our findings highlight significant variations in LOS across diagnostic categories, with AHF associated with the longest hospitalizations. The paradoxical association between hypertension and shorter stays suggests complex interactions between chronic conditions and acute care outcomes. Therefore, RDW represents a valuable prognostic tool, particularly when considered alongside diagnostic category and comorbidity profile.

List of Abbreviations

AF	Atrial Fibrillation
AHF	Acute Heart Failure
BMI	Body Mass Index
CBC	Complete Blood Cell Count
CICU	Cardiovascular Intensive Care Unit
CVD	Cardiovascular Disease
HF	Heart Failure
IHD	Ischemic Heart Disease
LOS	Length of Stay
MACE	Major Adverse Cardiac Events
RDW	Red Cell Distribution Width
RDW-CV	Red Cell Distribution Width – Coefficient of Variation
SD	Standard Deviation

Ethical Clearance

This study is a sub-analysis of a larger research project entitled "The Use of M-CARS and Bagaswoto Score in Predicting Mortality Rate and Hospitalization Length of Stay in Patient with Cardiovascular Intensive Care Unit" which received ethical approval from the Health Research Ethics Committee of RSUP Prof. Dr. R. D. Kandou Manado (Approval No. 061/EC/KEPK-KANDOU/V/2021, dated May 3, 2021). The data used in this sub-study were obtained from the same patient cohort as the parent study. As a member of the research team, the author was authorized to use the data for this specific analysis. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

Publication Approval

All authors are consent to the publication of this manuscript.

Authors Contributions

KSKS: Conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review & editing, visualization, project administration; ML: Supervision, writing – review & editing; DU: Supervision, writing – review & editing; FMY: Formal analysis, data curation, writing – review & editing; BO: Resources, supervision, writing – review & editing; RD: Investigation, data curation, writing – review & editing; CS: Investigation, data curation, writing – review & editing; J: Investigation, data curation, writing – review & editing.

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Conflict of Interest

None.

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Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the author(s) used ChatGPT solely for language polishing and grammar correction. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the final content of the publication. No AI tools were used for data analysis, interpretation, or generation of scientific ideas.

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