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"Correlation of Red Cell Distribution Width (RDW) with Heart Failure Severity and Clinical Outcomes: A Prospective Observational Study"

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ABSTRACT

Background

Heart failure (HF) is a major global public health problem associated with high morbidity, mortality, and healthcare expenditure. Red Cell Distribution Width (RDW), a routinely available hematological parameter reflecting erythrocyte size variability, has emerged as a potential prognostic biomarker in cardiovascular diseases. Elevated RDW has been linked with inflammation, oxidative stress, malnutrition, and poor cardiovascular outcomes.

Objective

To evaluate the correlation between RDW levels and severity of heart failure and to assess its association with clinical outcomes in patients admitted with heart failure.

Methods

A prospective observational study was conducted in the Department of General Medicine at Venkateshwara Institute of Medical Sciences, Gajraula, over a period of 18 months. A total of 120 patients diagnosed with heart failure were enrolled. RDW values were measured at admission and correlated with New York Heart Association (NYHA) functional class, left ventricular ejection fraction (LVEF), duration of hospital stay, and mortality outcomes. Statistical analysis was performed using SPSS version 26.0.

Results

Mean RDW levels were significantly elevated in patients with severe heart failure (NYHA class III and IV) compared to those with mild disease (NYHA class I and II). Higher RDW values showed negative correlation with LVEF and positive correlation with duration of hospitalization. Patients with RDW >15% demonstrated increased incidence of adverse clinical outcomes and prolonged hospital stay.

Conclusion

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Elevated RDW is significantly associated with increased severity of heart failure and poorer clinical outcomes. RDW may serve as a simple, inexpensive, and readily available prognostic marker in patients with heart failure.

KEYWORDS: Heart Failure; Red Cell Distribution Width; NYHA Classification; Ejection Fraction; Prognostic Marker; Cardiovascular Disease; Clinical Outcomes

INTRODUCTION

Heart failure (HF) represents one of the leading causes of hospitalization and mortality worldwide. It is a complex clinical syndrome resulting from structural or functional impairment of ventricular filling or ejection of blood, leading to inadequate systemic perfusion and increased intracardiac pressures (1). Despite substantial advancements in pharmacological and device-based therapies, heart failure continues to impose a considerable burden on healthcare systems globally.

According to the American Heart Association, approximately 64 million individuals worldwide suffer from heart failure, with increasing prevalence in developing countries due to aging populations, hypertension, diabetes mellitus, ischemic heart disease, and lifestyle modifications (2). In India, the prevalence of heart failure is rising rapidly because of increasing cardiovascular risk factors and delayed diagnosis, particularly in rural and semi-urban populations (3).

Heart failure is characterized by neurohormonal activation, inflammatory cytokine release, oxidative stress, endothelial dysfunction, and progressive myocardial remodeling (4). These pathophysiological mechanisms contribute not only to cardiac dysfunction but also to multisystem involvement affecting hematological, renal, hepatic, and metabolic pathways.

Red Cell Distribution Width (RDW) is a quantitative measure of heterogeneity in erythrocyte size and is routinely reported as part of complete blood count analysis. Traditionally, RDW has been utilized in the differential diagnosis of anemia. However, recent evidence suggests that elevated RDW is independently associated with adverse cardiovascular outcomes including coronary artery disease, atrial fibrillation, pulmonary hypertension, and heart failure (5).

Several mechanisms have been proposed linking elevated RDW with worsening heart failure. Chronic inflammation suppresses erythropoietin response and alters iron metabolism, resulting in ineffective erythropoiesis and anisocytosis (6). Oxidative stress may further shorten red blood cell survival and contribute to variability in cell morphology. Nutritional deficiencies, renal dysfunction, and neurohormonal activation commonly observed in heart failure patients additionally influence RDW levels (7).

Recent studies have demonstrated that elevated RDW correlates with increased mortality and rehospitalization among heart failure patients (8). Felker et al. reported that RDW was one of the strongest predictors of mortality in chronic heart failure (9). Similarly, Tonelli et al. observed a

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significant association between RDW and cardiovascular events independent of anemia status (10).

The New York Heart Association (NYHA) classification remains one of the most widely used clinical tools for assessing heart failure severity. Left ventricular ejection fraction (LVEF) also serves as an important echocardiographic parameter reflecting cardiac systolic function. Correlating RDW with NYHA class and LVEF may provide valuable prognostic information in resource-limited healthcare settings.

In tertiary care hospitals, identification of inexpensive and easily available prognostic biomarkers is essential for early risk stratification and management optimization. Since RDW is routinely available without additional financial burden, it may serve as a practical clinical indicator for assessing disease severity and predicting outcomes.

Despite increasing global interest in RDW as a cardiovascular biomarker, limited data are available from Indian tertiary care teaching institutions evaluating its relationship with heart failure severity and outcomes. Therefore, the present study was undertaken to evaluate the correlation between RDW and heart failure severity among hospitalized patients.

The primary objective of this study was to assess the relationship between RDW values and severity of heart failure based on NYHA classification and LVEF. Secondary objectives included evaluation of RDW association with duration of hospital stay and in-hospital clinical outcomes.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of General Medicine at Venkateshwara Institute of Medical Sciences, Gajraula, Uttar Pradesh, over a duration of 18 months from January 2024 to June 2025. The study included patients admitted with clinically and echocardiographically confirmed heart failure.

A total of 120 patients aged above 18 years diagnosed with heart failure according to European Society of Cardiology guidelines were enrolled in the study. Patients with acute blood loss, hematological malignancy, chronic liver disease, severe anemia unrelated to heart failure, recent blood transfusion, and active infection were excluded.

Detailed demographic and clinical history including age, sex, comorbidities, smoking status, hypertension, diabetes mellitus, and ischemic heart disease were recorded. Clinical examination was performed in all patients. Functional severity of heart failure was classified according to the New York Heart Association (NYHA) criteria.

Venous blood samples were collected at admission for complete blood count including RDW measurement using automated hematology analyzers. Echocardiography was performed to determine left ventricular ejection fraction (LVEF). Additional laboratory investigations including serum creatinine, electrolytes, blood glucose, and cardiac biomarkers were performed as indicated.

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Patients were monitored throughout hospitalization for duration of stay, complications, need for intensive care admission, and mortality outcomes. Ethical clearance was obtained from the Institutional Ethics Committee prior to study initiation, and informed consent was obtained from all participants.

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were represented as percentages. Pearson correlation coefficient, Student's t-test, Chi-square test, and ANOVA were applied where appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 120 patients with heart failure were included in the study. The mean age of participants was 58.4 ± 11.2 years, with male predominance (63.3%).

Table 1: Distribution of Patients According to NYHA Functional Class

NYHA Class	Number of Patients	Mean RDW (%)
Class I	14	12.8 ± 0.7
Class II	36	13.6 ± 0.9
Class III	44	15.1 ± 1.2
Class IV	26	16.4 ± 1.5

Interpretation

RDW values progressively increased with worsening NYHA functional class, indicating significant correlation between RDW elevation and severity of heart failure.

Table 2: Correlation Between RDW and Clinical Parameters

Parameter	RDW <15%	RDW >15%	p-value
Mean LVEF (%)	46.2 ± 5.4	32.8 ± 4.9	<0.001
Mean Hospital Stay (days)	5.1 ± 1.8	8.4 ± 2.2	<0.001
ICU Admission (%)	8.3%	28.6%	0.002
Mortality (%)	3.3%	14.3%	0.01

Interpretation

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Patients with elevated RDW (>15%) had significantly lower ejection fraction, prolonged hospitalization, increased ICU admission, and higher mortality.

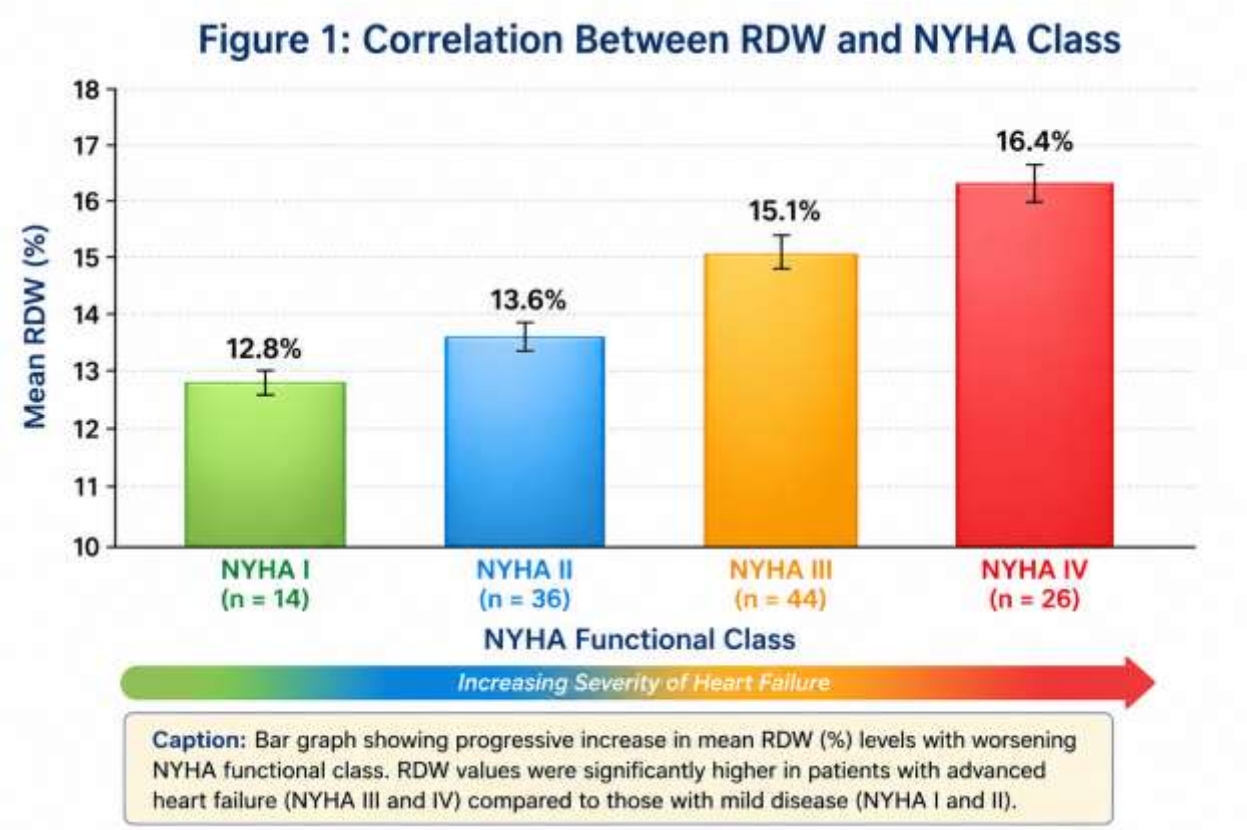

Figure 1: Correlation Between RDW and NYHA Class

Caption: Bar graph demonstrating progressive increase in RDW levels with worsening NYHA functional classification.

DISCUSSION

The present study evaluated the relationship between RDW and severity of heart failure among hospitalized patients. The findings demonstrated that elevated RDW levels were significantly associated with worsening NYHA class, reduced left ventricular ejection fraction, prolonged hospitalization, and adverse clinical outcomes.

Heart failure is increasingly recognized as a systemic inflammatory condition involving complex interactions between neurohormonal activation, oxidative stress, cytokine release, and metabolic dysfunction. These processes adversely affect erythropoiesis and contribute to anisocytosis reflected by increased RDW levels (11).

The current study observed progressive elevation of RDW values with increasing NYHA functional severity. Patients in NYHA class IV demonstrated the highest RDW levels compared

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with those in class I and II. Similar findings were reported by Förhécz et al., who identified elevated RDW as an independent predictor of advanced heart failure severity (12).

An important observation in the present study was the significant inverse correlation between RDW and left ventricular ejection fraction. Patients with elevated RDW had markedly reduced LVEF, indicating severe systolic dysfunction. This relationship may be explained by chronic inflammatory activation and impaired tissue oxygenation in advanced cardiac dysfunction (13).

Higher RDW levels were also associated with prolonged hospital stay and increased ICU admissions. Elevated RDW may therefore serve as a useful marker for identifying high-risk patients requiring intensive monitoring and aggressive treatment strategies. Al-Najjar et al. similarly demonstrated that RDW predicts long-term mortality and hospitalization in chronic heart failure patients (14).

The pathophysiological basis linking RDW with poor cardiovascular outcomes is multifactorial. Inflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha suppress bone marrow response and alter iron metabolism, resulting in release of immature erythrocytes into circulation (15). Oxidative stress additionally damages erythrocyte membranes, reducing cell survival and increasing size variability.

Nutritional deficiencies frequently observed in chronic heart failure including iron deficiency, vitamin B12 deficiency, and folate deficiency may further contribute to elevated RDW (16). Renal dysfunction associated with cardiorenal syndrome also impairs erythropoietin production and red blood cell maturation.

The current study demonstrated higher mortality among patients with RDW >15%. This finding is consistent with previous studies establishing RDW as an independent predictor of cardiovascular mortality (17). Since RDW measurement is inexpensive and routinely available, its incorporation into standard heart failure assessment protocols may improve early prognostication.

One of the strengths of the present study is its prospective design and comprehensive assessment of both clinical and echocardiographic parameters. However, certain limitations should be acknowledged. The study was conducted at a single tertiary care center with a relatively moderate sample size. Long-term follow-up after discharge was not performed. Additionally, inflammatory biomarkers such as CRP and interleukin levels were not evaluated.

Future multicentric studies with larger populations and long-term follow-up are necessary to validate RDW as a prognostic biomarker in diverse heart failure populations. Further research exploring combined biomarker models involving RDW, BNP, and inflammatory markers may enhance risk stratification strategies.

Overall, the present study supports the growing evidence that RDW is strongly associated with severity and adverse outcomes in heart failure. Its routine availability and low cost make it a valuable clinical tool, especially in resource-limited healthcare settings.

CONCLUSION

Elevated RDW levels are significantly associated with worsening heart failure severity, reduced left ventricular ejection fraction, prolonged hospital stay, increased ICU admission, and higher mortality. RDW serves as a simple, economical, and readily available prognostic marker that may aid in early risk stratification and clinical management of patients with heart failure.

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