

Association of Red Cell Distribution Width with In-Hospital Outcomes in Patients with Acute Myocardial Infarction

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ABSTRACT

Background: Red cell distribution width (RDW) is a routinely available hematological parameter that has been associated with adverse cardiovascular outcomes. However, evidence regarding its prognostic significance in Bangladeshi patients with acute myocardial infarction (AMI) is limited. **Objective:** To evaluate the association between admission RDW and in-hospital outcomes in patients with AMI. **Methods:** This prospective observational study included 70 consecutive adults with AMI admitted to the Department of Cardiology, Dhaka Medical College Hospital, Bangladesh, from January to December 2018. Demographic, clinical, laboratory, electrocardiographic and echocardiographic data were recorded. Patients were categorized into lower-RDW (n=38) and higher-RDW (n=32) groups. In-hospital mortality, heart failure, cardiogenic shock, arrhythmia, recurrent myocardial infarction, mechanical ventilation and prolonged hospitalization were assessed. Correlation and multivariable logistic regression analyses were performed. **Results:** The mean age was 58.7 ± 11.4 years, and 53 (75.7%) patients were male. STEMI occurred in 45 (64.3%) and NSTEMI in 25 (35.7%) patients. Mean admission RDW was $14.1 \pm 1.7\%$. Compared with the lower-RDW group, patients with higher RDW were older (62.6 ± 11.4 vs. 55.4 ± 10.6 years; $P=0.008$), had lower hemoglobin (11.9 ± 1.9 vs. 13.5 ± 1.4 g/dL; $P<0.001$), higher creatinine (1.25 ± 0.46 vs. 1.03 ± 0.24 mg/dL; $P=0.012$), and lower LVEF ($42.6 \pm 10.5\%$ vs. $49.2 \pm 8.1\%$; $P=0.004$). Heart failure (37.5% vs. 15.8%; $P=0.04$) and prolonged hospitalization (43.8% vs. 18.4%; $P=0.02$) were significantly more frequent in the higher-RDW group. Non-survivors had higher RDW than survivors ($16.1 \pm 1.7\%$ vs. $13.8 \pm 1.4\%$; $P<0.001$). RDW correlated positively with age, creatinine and hospital stay and inversely with hemoglobin and LVEF. Higher RDW remained independently associated with adverse in-hospital outcome (adjusted OR 2.84; 95% CI, 1.16–6.95; $P=0.022$). **Conclusion:** Elevated admission RDW was associated with greater disease severity, impaired ventricular function, heart failure, prolonged hospitalization and adverse in-hospital outcomes in patients with AMI. RDW may serve as a simple and inexpensive supplementary prognostic marker, although larger multicenter studies are needed to validate its clinical utility and optimal cutoff.

Keywords: acute myocardial infarction; red cell distribution width; RDW; in-hospital outcome; mortality; heart failure; prognosis.

INTRODUCTION

Acute myocardial infarction (AMI) remains one of the most important causes of cardiovascular morbidity and mortality worldwide. Despite substantial

improvements in reperfusion strategies, antiplatelet therapy, anticoagulation, lipid-lowering therapy and intensive cardiac care, patients with AMI continue to experience substantial risks of death and major

complications during hospitalization. Early identification of patients at increased risk is therefore essential for appropriate monitoring, treatment intensification and allocation of cardiovascular care resources. Risk assessment in AMI traditionally depends on clinical characteristics, electrocardiographic findings, cardiac biomarkers, hemodynamic status, renal function, left ventricular function and validated scores such as the Global Registry of Acute Coronary Events (GRACE) score. However, many of these parameters require specialized testing or complex calculation. Consequently, there is continuing interest in simple, inexpensive, routinely available laboratory markers that can provide additional prognostic information. Red cell distribution width (RDW) is a component of the standard complete blood count and represents the degree of variation in the size of circulating red blood cells. Increased RDW reflects anisocytosis and may result from disturbances in erythropoiesis, iron or vitamin deficiency, inflammation, oxidative stress, nutritional abnormalities, renal dysfunction and altered erythrocyte survival. These mechanisms are particularly relevant to cardiovascular disease because inflammation, oxidative stress, endothelial dysfunction and impaired tissue oxygen delivery contribute to myocardial injury and adverse remodeling. The association between RDW and cardiovascular outcomes was initially recognized in patients with heart failure and later extended to coronary artery disease and AMI. A large cohort study involving patients with AMI demonstrated a graded relationship between higher RDW and subsequent mortality, independent of conventional risk factors and anemia. The same study suggested that changes in RDW during hospitalization could also carry prognostic information.^[1] Evidence has subsequently accumulated showing that elevated RDW is associated with adverse outcomes in acute coronary syndrome (ACS). A meta-analysis involving 13 studies and 10,410 patients found that lower RDW was associated with substantially lower mortality and fewer major adverse cardiovascular events, supporting the potential value of RDW as an inexpensive prognostic marker.^[2] More recent studies have specifically examined the relationship between RDW and in-hospital mortality in AMI. Huang et al. reported that higher RDW was independently associated with in-hospital mortality among critically ill patients with AMI. Patients in the highest RDW tertile had significantly higher mortality than those in the lowest tertile and RDW values tended to increase among nonsurvivors during intensive care.^[3] The prognostic value of RDW may be related to several overlapping biological pathways. Systemic inflammation can suppress erythropoiesis and alter red-cell maturation. Oxidative stress may damage erythrocyte membranes and shorten red-cell survival. Renal dysfunction can contribute to impaired erythropoietin production, while nutritional

deficiencies may produce heterogeneous erythrocyte populations. In AMI, these mechanisms may coexist with myocardial necrosis, neurohormonal activation, tissue hypoperfusion and systemic inflammatory responses. Recent investigations have also examined combinations of RDW with other biomarkers. RDW-to-albumin ratio has been associated with in-hospital mortality in ICU patients with AMI, with evidence that the combined marker may outperform RDW or albumin alone.^[4] Similarly, studies of RDW-to-calcium ratio have explored whether combining RDW with biochemical indicators improves prediction of in-hospital mortality.^[5] A 2024 prospective study of patients with ST-segment elevation myocardial infarction (STEMI) found that RDW was associated with disease severity and in-hospital mortality. Higher RDW was observed among patients who died and RDW showed relationships with GRACE score and left ventricular ejection fraction.^[6] More recent evidence from a very large AMI cohort undergoing PCI has further supported the prognostic importance of elevated RDW, including among patients without anemia.^[7] Despite these findings, there remains a relative lack of clinical data from Bangladesh examining the relationship between RDW and in-hospital outcomes in AMI. Because RDW is inexpensive and available as part of routine hematological testing, establishing its prognostic significance could have practical value in resource-constrained cardiovascular settings. Therefore, the present study was designed to assess the association between admission RDW and in-hospital outcomes among patients with AMI admitted to the Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.

MATERIALS AND METHODS

Study design and setting

This prospective observational study was conducted in the Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh, over a period of 12 months, from January to December 2018. The study was designed to evaluate the association between admission red cell distribution width (RDW) and in-hospital outcomes among patients presenting with acute myocardial infarction (AMI).

Study population and sample size

The study population comprised consecutive adult patients admitted to the Department of Cardiology with a diagnosis of AMI during the study period. A total of 70 eligible patients were included in the analysis. AMI was diagnosed according to the clinical presentation, electrocardiographic findings and cardiac biomarker evidence of acute myocardial injury, consistent with contemporary diagnostic criteria. Patients were categorized as having ST-segment elevation myocardial infarction (STEMI) or non-ST-segment elevation myocardial infarction (NSTEMI)

according to their clinical and electrocardiographic presentation.

Inclusion criteria

Patients were included if they fulfilled the following criteria:

1. Age ≥ 18 years.
2. Confirmed diagnosis of acute myocardial infarction.
3. Admission to the Department of Cardiology during the study period.
4. Availability of an admission complete blood count including RDW.
5. Availability of relevant clinical and outcome data during hospitalization.

Exclusion criteria

Patients were excluded if they had conditions that could substantially influence RDW independently of AMI, including known hematological malignancy, hemoglobinopathy, recent blood transfusion, active major bleeding, pregnancy, severe infection or sepsis, or incomplete clinical or laboratory records. Patients with other major conditions known to markedly alter erythrocyte morphology were also excluded where clinically identifiable.

Data collection

After admission, demographic and clinical information was recorded using a structured data collection form. Demographic variables included age and sex. Relevant cardiovascular risk factors included diabetes mellitus, hypertension, dyslipidemia, current smoking, previous myocardial infarction and previous coronary artery disease. At presentation, systolic and diastolic blood pressure, pulse rate, clinical signs of heart failure and Killip class were documented. Killip class was categorized from I to IV according to the presence and severity of clinical heart failure or cardiogenic shock. Electrocardiography was performed at admission and patients were classified as STEMI or NSTEMI. Details regarding initial medical treatment and relevant in-hospital interventions were recorded where available.

Laboratory investigations

Venous blood samples were obtained at admission before or early during hospital treatment. Complete blood count was performed using the hospital laboratory's automated hematology analyzer. RDW was recorded directly from the initial complete blood count report and expressed as a percentage. Hemoglobin, total leukocyte count, platelet count and other hematological parameters were also recorded. Serum creatinine, blood glucose, cardiac biomarkers and lipid profile were measured according to the routine laboratory protocols of the hospital. The admission RDW value was used for the primary analysis to ensure that the measurement preceded the subsequent in-hospital outcomes.

Echocardiographic assessment

Two-dimensional transthoracic echocardiography was performed during hospitalization. Left ventricular ejection fraction (LVEF) was recorded as an indicator of left ventricular systolic function. The echocardiographic assessment was performed according to the routine clinical protocol of the cardiology department.

Classification according to RDW

Patients were divided into two groups according to their admission RDW:

- **Lower-RDW group:** 38 patients (54.3%)
- **Higher-RDW group:** 32 patients (45.7%)

The RDW cutoff used for categorization should be explicitly reported in the final manuscript according to the original study protocol or laboratory reference range. Because the exact numerical cutoff was not provided in the available study information, it should not be retrospectively invented.

Assessment of in-hospital outcomes

Patients were followed prospectively from admission until hospital discharge or death.

The **primary outcome** was in-hospital mortality.

Secondary outcomes included:

- acute heart failure;
- cardiogenic shock;
- significant cardiac arrhythmia;
- recurrent myocardial infarction;
- requirement for mechanical ventilation; and
- prolonged hospitalization.

For the final analysis, prolonged hospitalization should be defined using the prespecified duration used in the original study protocol. If no predefined threshold was used, the definition should be stated according to the actual statistical analysis. An overall **adverse in-hospital outcome** variable was used for multivariable analysis. The final manuscript should specify precisely which individual outcomes were included in this composite endpoint.

Statistical analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean $\pm$ standard deviation (SD) when normally distributed, while categorical variables were expressed as frequencies and percentages. The distribution of continuous variables was assessed before selection of statistical tests. Comparisons between the lower- and higher-RDW groups were performed using the independent-samples Student's *t* test for normally distributed continuous variables or the Mann–Whitney *U* test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. The association between RDW and selected continuous

variables, including age, hemoglobin, serum creatinine, LVEF and duration of hospitalization, was assessed using Pearson's or Spearman's correlation coefficient according to the distribution of the data. To identify factors independently associated with adverse in-hospital outcome, multivariable binary logistic regression analysis was performed. Variables considered clinically relevant or showing evidence of association in univariable analysis were entered into the multivariable model. The model included age, diabetes mellitus, hypertension, hemoglobin, serum creatinine, LVEF and RDW category. Results were expressed as adjusted odds ratios (ORs) with corresponding 95% confidence intervals (CIs). A two-tailed *P* value <0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval should be reported using the **actual name of the institutional ethics committee and approval/reference number** from the original study. Written informed consent should also be stated according to the procedure actually followed during patient recruitment.

Methodological considerations

Because RDW may be influenced by anemia, nutritional deficiency, renal dysfunction, inflammation and other systemic conditions, these potential confounding factors were considered during interpretation and multivariable analysis. The study was designed to assess the **association** between admission RDW and clinical outcomes and therefore

does not establish a causal relationship between elevated RDW and adverse outcomes. The prospective design, consecutive enrollment, use of an admission RDW measurement and systematic assessment of clinically relevant in-hospital outcomes were intended to minimize selection and temporal bias and to evaluate the potential utility of RDW as an inexpensive prognostic marker in patients with AMI.

RESULTS

Baseline demographic and clinical characteristics

A total of 70 patients with acute myocardial infarction were included in the study. The mean age of the study population was 58.7 ± 11.4 years. Of the total participants, 53 (75.7%) were male and 17 (24.3%) were female, giving a male-to-female ratio of approximately 3.1:1. Diabetes mellitus was present in 27 (38.6%) patients, while 31 (44.3%) had hypertension. Dyslipidemia was documented in 22 (31.4%) patients and 34 (48.6%) were current smokers. Previous myocardial infarction was reported in 13 (18.6%) patients, whereas 19 (27.1%) had a previous history of coronary artery disease. Regarding the type of myocardial infarction, STEMI was more common than NSTEMI, accounting for 45 (64.3%) and 25 (35.7%) patients, respectively. The mean systolic and diastolic blood pressures at presentation were 118.6 ± 19.7 mmHg and 73.4 ± 11.2 mmHg, respectively. The mean hemoglobin concentration was 12.8 ± 1.8 g/dL. The mean admission RDW was $14.1 \pm 1.7\%$, while the mean LVEF was $46.2 \pm 9.8\%$. Overall, the study population consisted predominantly of middle-aged to older men with a substantial prevalence of conventional cardiovascular risk factors.

Table 1. Baseline demographic and clinical characteristics of the study population (n=70)

Variable	Total (n=70)
Age, years, mean $\pm$ SD	58.7 ± 11.4
Male sex, n (%)	53 (75.7)
Female sex, n (%)	17 (24.3)
Diabetes mellitus, n (%)	27 (38.6)
Hypertension, n (%)	31 (44.3)
Dyslipidemia, n (%)	22 (31.4)
Current smoker, n (%)	34 (48.6)
Previous MI, n (%)	13 (18.6)
Previous CAD, n (%)	19 (27.1)
STEMI, n (%)	45 (64.3)
NSTEMI, n (%)	25 (35.7)
Systolic BP, mmHg, mean $\pm$ SD	118.6 ± 19.7
Diastolic BP, mmHg, mean $\pm$ SD	73.4 ± 11.2
Hemoglobin, g/dL, mean $\pm$ SD	12.8 ± 1.8
RDW, %, mean $\pm$ SD	14.1 ± 1.7
LVEF, %, mean $\pm$ SD	46.2 ± 9.8

Abbreviations: BP, blood pressure; CAD, coronary artery disease; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NSTEMI, non-ST-segment elevation myocardial infarction; RDW, red cell distribution width; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction.

Distribution according to admission RDW

Patients were categorized into lower and higher RDW groups according to the predefined study classification. Of the 70 patients, 38 (54.3%) were classified into the lower-RDW group, whereas 32 (45.7%) were classified into the higher-RDW group. Thus, nearly half of the study population had an elevated admission RDW. The distribution demonstrates a relatively balanced comparison between the two RDW categories, allowing assessment of differences in baseline characteristics and clinical outcomes between the groups.

Table 2. Distribution of patients according to admission RDW

RDW category	Number	Percentage
Lower RDW	38	54.3
Higher RDW	32	45.7
Total	70	100.0

Abbreviation: RDW, red cell distribution width.

Comparison of baseline characteristics according to RDW category

There were significant differences in several baseline characteristics between the lower- and higher-RDW groups. Patients with higher RDW were significantly older than those with lower RDW (62.6 ± 11.4 vs. 55.4 ± 10.6 years; $P=0.008$). Hemoglobin concentration was significantly lower among patients with higher RDW compared with those with lower RDW (11.9 ± 1.9 vs. 13.5 ± 1.4 g/dL; $P<0.001$). Similarly, serum creatinine was significantly higher in the higher-RDW group (1.25 ± 0.46 vs. 1.03 ± 0.24 mg/dL; $P=0.012$). Left ventricular systolic function also differed significantly between the groups. Patients with higher RDW had a lower mean LVEF than patients with lower RDW ($42.6 \pm 10.5\%$ vs. $49.2 \pm 8.1\%$; $P=0.004$). Diabetes mellitus and hypertension were more frequent among patients with higher RDW, although these differences did not reach statistical significance. Similarly, STEMI was more frequent in the higher-RDW group than in the lower-RDW group (75.0% vs. 55.3%), but the difference was not statistically significant ($P=0.09$). Sex distribution and smoking status were comparable between the two groups.

Table 3. Comparison of baseline characteristics between lower- and higher-RDW groups

Variable	Lower RDW (n=38)	Higher RDW (n=32)	P value
Age, years, mean $\pm$ SD	55.4 ± 10.6	62.6 ± 11.4	0.008
Male sex, n (%)	29 (76.3)	24 (75.0)	0.90
Diabetes mellitus, n (%)	11 (28.9)	16 (50.0)	0.07
Hypertension, n (%)	14 (36.8)	17 (53.1)	0.18
Smoking, n (%)	20 (52.6)	14 (43.8)	0.47
Hemoglobin, g/dL, mean $\pm$ SD	13.5 ± 1.4	11.9 ± 1.9	<0.001
Creatinine, mg/dL, mean $\pm$ SD	1.03 ± 0.24	1.25 ± 0.46	0.012
LVEF, %, mean $\pm$ SD	49.2 ± 8.1	42.6 ± 10.5	0.004
STEMI, n (%)	21 (55.3)	24 (75.0)	0.09

Abbreviations: LVEF, left ventricular ejection fraction; RDW, red cell distribution width; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction.

Distribution of Killip class according to RDW

The distribution of Killip class differed between the two RDW groups. Among patients with lower RDW, 28 (73.7%) were classified as Killip class I, 7 (18.4%) as class II, 2 (5.3%) as class III and 1 (2.6%) as class IV. In contrast, among patients with higher RDW, 16 (50.0%) were in Killip class I, 8 (25.0%) in class II, 5 (15.6%) in class III and 3 (9.4%) in class IV. Thus, the proportion of patients with more advanced Killip classes III and IV was higher among those with elevated RDW. Collectively, 8 (25.0%) patients in the higher-RDW group were classified as Killip III or IV compared with 3 (7.9%) in the lower-RDW group, indicating a greater burden of clinical heart failure and hemodynamic compromise among patients with higher RDW.

Table 4. Distribution of Killip class according to RDW category

Killip class	Lower RDW (n=38), n (%)	Higher RDW (n=32), n (%)
I	28 (73.7)	16 (50.0)
II	7 (18.4)	8 (25.0)
III	2 (5.3)	5 (15.6)
IV	1 (2.6)	3 (9.4)

Abbreviation: RDW, red cell distribution width.

In-hospital outcomes according to RDW category

Adverse in-hospital outcomes were more frequently observed among patients with higher RDW. In-hospital mortality occurred in 6 (18.8%) patients in the higher-RDW group compared with 2 (5.3%) patients in the lower-RDW group. Although the mortality difference did not reach statistical significance ($P=0.08$), the absolute proportion was more than three times higher in patients with elevated RDW. Heart failure was significantly more frequent among patients with higher RDW than among those with lower RDW (37.5% vs. 15.8%; $P=0.04$). Cardiogenic shock occurred in 15.6% of patients in the higher-RDW group compared with 2.6% in the lower-RDW group ($P=0.08$). Significant arrhythmia was also more frequent in the higher-RDW group (25.0% vs. 10.5%; $P=0.10$). Recurrent myocardial infarction occurred in 9.4% of patients with higher RDW compared with 2.6% among those with lower RDW ($P=0.23$). Similarly, mechanical ventilation was required in 15.6% of patients with higher RDW compared with 2.6% of patients with lower RDW ($P=0.08$). Prolonged hospitalization was significantly more common among patients with higher RDW (43.8%) than among those with lower RDW (18.4%; $P=0.02$). Overall, the findings demonstrate a consistent pattern of greater clinical morbidity among patients presenting with higher RDW, with statistically significant differences observed for heart failure and prolonged hospitalization.

Table 5. In-hospital outcomes according to RDW category

Outcome	Lower RDW (n=38), n (%)	Higher RDW (n=32), n (%)	P value
In-hospital mortality	2 (5.3)	6 (18.8)	0.08
Heart failure	6 (15.8)	12 (37.5)	0.04
Cardiogenic shock	1 (2.6)	5 (15.6)	0.08
Significant arrhythmia	4 (10.5)	8 (25.0)	0.10
Recurrent MI	1 (2.6)	3 (9.4)	0.23
Mechanical ventilation	1 (2.6)	5 (15.6)	0.08
Prolonged hospitalization	7 (18.4)	14 (43.8)	0.02

Abbreviations: MI, myocardial infarction; RDW, red cell distribution width.

Comparison of clinical and laboratory characteristics according to in-hospital survival

Of the 70 patients included in the study, 62 survived to hospital discharge, while 8 died during hospitalization. Patients who died were significantly older than survivors (67.3 ± 12.7 vs. 57.6 ± 10.8 years; $P=0.018$). A marked difference was observed in admission RDW. Non-survivors had a significantly higher mean RDW than survivors ($16.1 \pm 1.7\%$ vs. $13.8 \pm 1.4\%$; $P<0.001$). Hemoglobin was significantly lower among non-survivors (11.2 ± 1.5 vs. 13.0 ± 1.7 g/dL; $P=0.004$), while serum creatinine was significantly higher (1.41 ± 0.51 vs. 1.07 ± 0.31 mg/dL; $P=0.006$). Left ventricular systolic function was also significantly poorer among patients who died. The mean LVEF was $37.1 \pm 9.5\%$ among non-survivors compared with $47.4 \pm 8.7\%$ among survivors ($P=0.002$). STEMI was present in all 8 non-survivors compared with 37 (59.7%) survivors, representing a statistically significant difference ($P=0.03$). Taken together, the results demonstrate that in-hospital death was associated with higher admission RDW, older age, lower hemoglobin, greater renal dysfunction, reduced LVEF and STEMI presentation.

Table 6. Comparison of clinical and laboratory parameters according to in-hospital survival

Variable	Survivors (n=62)	Non-survivors (n=8)	P value
Age, years, mean $\pm$ SD	57.6 ± 10.8	67.3 ± 12.7	0.018
RDW, %, mean $\pm$ SD	13.8 ± 1.4	16.1 ± 1.7	<0.001
Hemoglobin, g/dL, mean $\pm$ SD	13.0 ± 1.7	11.2 ± 1.5	0.004
Creatinine, mg/dL, mean $\pm$ SD	1.07 ± 0.31	1.41 ± 0.51	0.006
LVEF, %, mean $\pm$ SD	47.4 ± 8.7	37.1 ± 9.5	0.002
STEMI, n (%)	37 (59.7)	8 (100.0)	0.03

Abbreviations: LVEF, left ventricular ejection fraction; RDW, red cell distribution width; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction.

Correlation between RDW and selected clinical parameters

Correlation analysis demonstrated several significant relationships between admission RDW and clinical or laboratory parameters. RDW showed a positive correlation with age ($r=0.29$, $P=0.014$), indicating that RDW tended to increase with advancing age. A stronger inverse correlation was observed between RDW and hemoglobin ($r=-0.51$, $P<0.001$), demonstrating that higher RDW was associated with lower hemoglobin concentration. RDW also demonstrated a positive correlation with serum creatinine ($r=0.30$, $P=0.011$), suggesting an association between increased anisocytosis and impaired renal function. In contrast, RDW was inversely correlated with LVEF ($r=-0.34$, $P=0.004$), indicating that higher RDW was associated with poorer left ventricular systolic function. A significant positive correlation was also observed between RDW and duration of hospitalization ($r=0.36$, $P=0.002$). Thus, patients with higher admission RDW tended to have a longer hospital stay.

Table 7. Correlation between RDW and selected clinical and laboratory variables

Variable	Correlation coefficient (r)	P value
Age	+0.29	0.014
Hemoglobin	−0.51	<0.001
Creatinine	+0.30	0.011
LVEF	−0.34	0.004
Hospital stay	+0.36	0.002

Abbreviation: RDW, red cell distribution width.

Multivariable logistic regression analysis

Multivariable logistic regression was performed to identify independent predictors of adverse in-hospital outcome. After adjustment for age, diabetes mellitus, hypertension, hemoglobin, serum creatinine, LVEF and RDW category, several variables remained associated with adverse outcome. Age was independently associated with adverse outcome, with each one-year increase associated with a 5% increase in the odds of adverse outcome (adjusted OR [aOR], 1.05; 95% CI, 1.01–1.10; $P=0.021$). Hemoglobin demonstrated an inverse association with adverse outcome (aOR, 0.78; 95% CI, 0.61–0.99; $P=0.041$), whereas serum creatinine was positively associated with adverse outcome (aOR, 1.92; 95% CI, 1.08–3.42; $P=0.027$). LVEF was inversely associated with adverse outcome (aOR, 0.94; 95% CI, 0.89–0.99; $P=0.032$), indicating that lower ventricular systolic function was associated with increased risk. Diabetes mellitus and hypertension were not independently associated with the outcome after adjustment. Importantly, higher RDW remained independently associated with adverse in-hospital outcome after adjustment for the other variables included in the model. Patients with higher RDW had approximately 2.84-fold higher odds of adverse outcome than those with lower RDW (aOR, 2.84; 95% CI, 1.16–6.95; $P=0.022$).

Table 8. Multivariable logistic regression analysis of predictors of adverse in-hospital outcome

Predictor	Adjusted OR	95% CI	P value
Age	1.05	1.01–1.10	0.021
Diabetes mellitus	1.42	0.63–3.21	0.390
Hypertension	1.26	0.57–2.79	0.570
Hemoglobin	0.78	0.61–0.99	0.041
Creatinine	1.92	1.08–3.42	0.027
LVEF	0.94	0.89–0.99	0.032
Higher RDW	2.84	1.16–6.95	0.022

Abbreviations: CI, confidence interval; LVEF, left ventricular ejection fraction; OR, odds ratio; RDW, red cell distribution width.

DISCUSSION

The present study evaluated the prognostic significance of admission RDW among patients with AMI and demonstrated that higher RDW was associated with a less favorable clinical profile and increased frequency of adverse in-hospital outcomes. Patients with higher RDW were older and had lower hemoglobin, higher creatinine, poorer left ventricular systolic function and a greater proportion of advanced Killip classes. Importantly, heart failure and prolonged hospitalization were significantly more frequent among patients with higher RDW, while non-survivors had substantially higher admission RDW than survivors. After multivariable adjustment, elevated RDW remained independently associated with adverse in-hospital outcome. These findings are consistent with recent evidence supporting RDW as an accessible prognostic marker in AMI. A 2024 cohort study specifically examining NSTEMI patients found that individuals with higher RDW were older and had a higher burden of previous MI, inflammatory abnormalities, lower albumin and reduced ejection fraction. During follow-up, mortality was markedly

higher in the high-RDW group, supporting the association between RDW and adverse prognosis in myocardial infarction.^[6] The present finding of a significantly lower LVEF among patients with elevated RDW is clinically relevant. In our study, mean LVEF was $42.6 \pm 10.5\%$ in the higher-RDW group compared with $49.2 \pm 8.1\%$ in the lower-RDW group ($P=0.004$). A recent prospective study of STEMI patients similarly reported an association between elevated RDW, disease severity and in-hospital mortality. The investigators also demonstrated an inverse relationship between RDW and LVEF, suggesting that increased anisocytosis may reflect a greater burden of myocardial injury and systemic physiological stress.^[7] The relationship between RDW and mortality observed in our study is particularly noteworthy. Although mortality was not statistically significant between the two RDW categories, mortality occurred in 18.8% of patients with higher RDW compared with 5.3% of those with lower RDW. Moreover, the mean admission RDW was significantly higher among non-survivors than survivors ($16.1 \pm 1.7\%$ vs. $13.8 \pm 1.4\%$; $P<0.001$). This pattern is compatible with larger

observational studies showing that elevated RDW is associated with mortality after AMI. Recent large-scale evidence has strengthened this association. In a 2026 propensity-score-matched cohort involving more than 64,000 AMI patients undergoing PCI, elevated RDW was independently associated with increased one-year mortality and several major cardiovascular complications. High RDW was associated with mortality, heart failure, cardiogenic shock, recurrent AMI, cerebrovascular events and arrhythmia. Importantly, the association with mortality persisted among patients without anemia, indicating that RDW may provide prognostic information beyond hemoglobin concentration alone.^[8] Our observation that higher RDW was associated with lower hemoglobin is also biologically plausible. RDW reflects heterogeneity in erythrocyte size and can increase in the presence of nutritional deficiency, impaired erythropoiesis, inflammation, renal dysfunction and altered red-cell survival. However, the relationship between RDW and cardiovascular prognosis cannot be explained solely by anemia. The recent large AMI cohort demonstrated persistent prognostic significance of RDW even in patients without anemia.^[8] In the present study, serum creatinine was significantly higher among patients with elevated RDW (1.25 ± 0.46 vs. 1.03 ± 0.24 mg/dL; $P=0.012$). RDW also demonstrated a positive correlation with creatinine ($r=0.30$, $P=0.011$). This relationship may reflect the interaction between renal dysfunction, impaired erythropoiesis, inflammation and cardiovascular disease severity. Renal dysfunction is itself an established adverse prognostic marker in AMI and the simultaneous elevation of RDW and creatinine may identify patients with a greater systemic disease burden. The association between RDW and heart failure in our study is also important. Heart failure occurred in 37.5% of patients with higher RDW compared with 15.8% of patients with lower RDW ($P=0.04$). Recent studies have similarly linked increased RDW with adverse cardiovascular events and heart failure. The large 2026 AMI cohort reported significantly increased risk of heart failure among patients with elevated RDW, further supporting our observation.^[8] The relationship between RDW and prolonged hospitalization was another important finding. In our cohort, prolonged hospitalization occurred in 43.8% of patients with higher RDW compared with 18.4% of patients with lower RDW ($P=0.02$). RDW also demonstrated a positive correlation with duration of hospitalization ($r=0.36$, $P=0.002$). This may reflect the fact that patients with elevated RDW have greater systemic illness, more severe myocardial dysfunction, anemia, renal impairment and a higher incidence of complications requiring prolonged treatment and monitoring. Recent research has also moved beyond RDW alone toward composite indices incorporating RDW with other routinely available biomarkers. A 2023 study

evaluating the RDW-to-albumin ratio in AMI found that a higher ratio was associated with increased mortality and demonstrated better predictive performance than RDW or albumin alone.^[9] These findings suggest that RDW may represent one component of a broader biological profile involving inflammation, nutritional status and tissue injury. Similarly, RDW-based inflammatory or hematological ratios have recently been evaluated for risk prediction in AMI. A study using the MIMIC-IV database found that the RDW-to-platelet ratio was independently associated with mortality among patients with AMI, suggesting that combining RDW with another routinely available hematological parameter may improve prognostic assessment.^[10] Another recent investigation examined the RDW-to-calcium ratio in ICU patients with AMI. After propensity-score adjustment, patients with a higher ratio had a significantly greater risk of in-hospital mortality, supporting the concept that RDW may have greater prognostic utility when integrated with other biochemical markers.^[11] The association between RDW and adverse cardiovascular outcomes is not restricted to short-term mortality. A 2023 study involving patients with ACS found that higher RDW was associated with an increased risk of major adverse cardiovascular events during follow-up. The association remained significant in multivariable analysis, indicating that RDW may capture long-term cardiovascular risk as well as acute disease severity.^[12] The current findings are also consistent with the broader evidence summarized in previous meta-analytic work. A meta-analysis involving more than 10,000 patients with ACS demonstrated that lower RDW was associated with lower mortality and fewer major adverse cardiovascular events.^[13] Although the present study was smaller and focused specifically on in-hospital outcomes, the direction of association is consistent with this larger body of evidence. An important aspect of the current study is the significant inverse correlation between RDW and LVEF. Higher RDW was associated with lower LVEF ($r=-0.34$, $P=0.004$). This may indicate that RDW reflects the cumulative effects of inflammation, oxidative stress, anemia, renal dysfunction and impaired tissue oxygen delivery, all of which may contribute to myocardial dysfunction. Recent NSTEMI research has similarly demonstrated that patients with high RDW had lower ejection fraction and a more unfavorable inflammatory and clinical profile.^[6] Our multivariable analysis further supports the potential independent prognostic value of RDW. After adjustment for age, diabetes, hypertension, hemoglobin, creatinine and LVEF, higher RDW was associated with 2.84-fold higher odds of adverse in-hospital outcome (95% CI 1.16–6.95; $P=0.022$). This is clinically relevant because these conventional variables represent several major pathways associated with poor AMI outcomes. The persistence of RDW in the adjusted model suggests

that it may capture additional biological information not completely represented by conventional cardiovascular risk factors. Nevertheless, RDW should not be considered a replacement for established AMI risk scores. Rather, it may serve as an inexpensive adjunctive marker that can complement clinical assessment, Killip class, renal function, LVEF, cardiac biomarkers and validated risk scores. Its major practical advantage is that RDW is routinely generated as part of the complete blood count and therefore requires no additional testing. The biological mechanisms underlying the association between elevated RDW and AMI outcomes are likely multifactorial. Inflammation can impair erythrocyte maturation, oxidative stress can alter erythrocyte membrane integrity, renal dysfunction can affect erythropoiesis and nutritional abnormalities can increase heterogeneity in red-cell size. Acute myocardial injury itself produces systemic inflammatory and neurohormonal responses that may further increase RDW. Thus, RDW may function primarily as an integrated marker of systemic physiological stress rather than as a direct causal mediator. The present study has several strengths. It was prospective in design, included consecutive patients with AMI, assessed RDW at admission and evaluated multiple clinically relevant in-hospital outcomes. The use of a routinely available hematological parameter makes the findings potentially relevant to resource-limited cardiovascular settings such as Bangladesh. Several limitations should also be acknowledged. The sample size was relatively small, with only 70 patients and eight in-hospital deaths. Consequently, the study may have limited statistical power for detecting differences in relatively infrequent outcomes such as cardiogenic shock, recurrent MI and mortality. The single-center design limits generalizability. In addition, RDW may be influenced by anemia, nutritional deficiency, renal dysfunction, inflammation and other non-cardiac conditions. Finally, a single admission RDW measurement does not assess temporal changes during hospitalization. Despite these limitations, the present findings add to the growing evidence that admission RDW is associated with disease severity and adverse outcomes in AMI. The results suggest that patients with elevated RDW may represent a clinically higher-risk subgroup requiring closer assessment and monitoring. Future multicenter studies in Bangladesh with larger sample sizes should validate the optimal RDW threshold and determine whether incorporating RDW into established AMI risk scores improves prediction of in-hospital mortality and major adverse cardiovascular events.

Strengths of the Study

The major strengths of this study include its prospective observational design, consecutive enrollment of AMI patients, assessment of RDW at the

time of admission and evaluation of clinically meaningful in-hospital outcomes. RDW is inexpensive, routinely available and requires no additional specialized laboratory testing. The study therefore addresses a clinically relevant question with potential applicability to resource-limited cardiovascular care.

Limitations

The relatively small sample size of 70 patients represents the principal limitation. The single-center setting may reduce generalizability. Potential residual confounding by anemia, nutritional deficiency, renal disease, inflammatory conditions and other factors affecting RDW cannot be completely excluded. The study also does not establish whether interventions directed at the underlying causes of elevated RDW improve outcomes.

CONCLUSION

In this prospective observational study of patients with acute myocardial infarction, elevated admission red cell distribution width (RDW) was associated with a more adverse clinical profile and poorer in-hospital outcomes. Patients with higher RDW were older and had lower hemoglobin levels, higher serum creatinine concentrations, lower left ventricular ejection fraction and a greater proportion of advanced Killip classes. Higher RDW was also significantly associated with in-hospital heart failure and prolonged hospitalization. Patients who died during hospitalization had significantly higher admission RDW than survivors and RDW showed significant correlations with age, hemoglobin, serum creatinine, left ventricular ejection fraction and duration of hospitalization. After adjustment for selected clinical and laboratory variables, higher RDW remained independently associated with adverse in-hospital outcome, with approximately 2.8-fold higher odds. These findings suggest that RDW, a routinely available and inexpensive parameter obtained from the complete blood count, may provide useful supplementary prognostic information in patients with AMI, particularly in resource-limited settings. However, RDW should be interpreted together with established clinical, biochemical and echocardiographic risk indicators rather than used as a standalone prognostic marker. Larger multicenter prospective studies in Bangladesh are warranted to validate the optimal RDW cutoff and determine whether incorporation of RDW into established AMI risk-stratification models improves prediction of in-hospital mortality and major cardiovascular complications.

Recommendations

1. RDW should be recorded routinely in the initial hematological assessment of patients with AMI.
2. Patients with markedly elevated RDW may warrant closer clinical monitoring, particularly when

accompanied by anemia, renal dysfunction, reduced LVEF, or high Killip class.

3. Future studies should evaluate serial RDW measurements during hospitalization.
4. Larger multicenter studies should establish a population-specific RDW cutoff for Bangladeshi patients.
5. Future research should assess whether adding RDW to GRACE or other established risk scores improves prognostic discrimination.
6. Combined biomarkers such as RDW/albumin ratio may be evaluated as potential alternatives to RDW alone.

Declarations

Ethics approval

The final submitted manuscript should include the name of the institutional ethics committee/IRB that approved the original study and the approval/reference number.

Informed consent

The final manuscript should state the actual consent procedure used in the original study.

Conflict of interest

The authors should declare any actual conflicts of interest.

Funding

The authors should state the actual source of funding, or state that no specific funding was received if applicable.

Data availability

The final manuscript should include the actual data-availability statement according to institutional and journal requirements.

Author contributions

Author contributions should be reported according to the actual contributions of each author.

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