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Original Research Article

ASSOCIATION OF RED CELL DISTRIBUTION WIDTH WITH GLYCEMIC CONTROL IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CASE-CONTROL STUDY

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ABSTRACT

Background: Red cell distribution width (RDW) is a routinely available hematological parameter that reflects variability in erythrocyte size and has emerged as a potential marker of systemic inflammation and metabolic disturbances. Its association with glycemic control in type 2 diabetes mellitus (T2DM) has gained increasing clinical interest. **Materials and Methods:** This hospital-based case-control study included 452 patients with T2DM attending Government Medical College Hospital, Thiruvallur, between June and August 2024. Patients were classified into controlled (n = 226) and uncontrolled (n = 226) diabetes groups according to American Diabetes Association HbA1c criteria. RDW values were categorized into three groups: Q1 (11.0–12.9%), Q2 (13.0–13.9%), and Q3 (>14.0%). RDW distribution, odds ratios, and age and sex distribution across RDW and HbA1c categories were analyzed using the Chi-square test. **Results:** Among controlled diabetic patients, 89 (39.4%), 70 (31.0%), and 67 (29.6%) belonged to Q1, Q2, and Q3, respectively, whereas among uncontrolled patients, 68 (30.1%), 87 (38.5%), and 71 (31.4%) belonged to the corresponding groups. Patients in Q2 and Q3 had 1.6-fold and 1.3-fold higher odds of uncontrolled diabetes than those in Q1 ($p < 0.05$). The mean age across RDW groups ranged from 57.71 ± 1.12 to 60.21 ± 0.90 years, while the highest mean age was observed in the HbA1c-3 category (63.39 ± 1.17 years). **Conclusion:** Higher RDW values were associated with poor glycemic control in patients with T2DM. RDW may serve as a simple, inexpensive, and readily available hematological marker for identifying patients with uncontrolled diabetes and may complement routine glycemic assessment.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most common chronic metabolic disorders worldwide and is characterised by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both. The global prevalence of diabetes continues to rise, making it a major public health concern due to its associated morbidity, mortality, and economic burden. Long-term poor glycemic control contributes to the development of microvascular complications such as diabetic retinopathy, nephropathy, and neuropathy, as well as macrovascular complications including coronary artery disease and stroke. Therefore, early identification of patients at risk of poor glycemic control is essential for timely intervention and prevention of complications.[1-4]

Persistent hyperglycemia affects various physiological processes, including the structure and function of red blood cells (RBCs). Chronic exposure to elevated glucose levels leads to non-enzymatic glycation of membrane proteins, oxidative stress, and reduced membrane flexibility. These changes shorten RBC survival and increase variability in cell size, which is reflected by an increase in red cell distribution width (RDW). RDW is a routinely reported parameter in the complete blood count and measures the degree of variation in the size of circulating erythrocytes. Although traditionally used in the evaluation of different types of anemia, RDW has recently gained attention as a potential marker of systemic inflammation, oxidative stress, and metabolic disorders.[5-6]

Several studies have reported that elevated RDW is associated with poor glycemic control and an

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increased risk of diabetic complications. Higher RDW values have been linked with elevated glycated hemoglobin (HbA1c) levels, longer duration of diabetes, and a greater incidence of cardiovascular and renal complications. Since RDW is inexpensive, readily available, and routinely measured in clinical practice, it has the potential to serve as a simple adjunctive marker for assessing glycemic status in patients with diabetes. Despite these observations, the relationship between RDW and glycemic control has not been consistently evaluated across different populations, and evidence from Indian hospital-based studies remains limited.[7-9]

Assessment of RDW in patients with controlled and uncontrolled diabetes may provide valuable information regarding its association with glycemic status. In addition, evaluating demographic characteristics such as age and sex across RDW and HbA1c categories may help describe the distribution of these parameters among diabetic patients. Such information may support the clinical utility of RDW as an easily accessible hematological parameter in routine diabetic care.[8,9]

Therefore, the present case-control study was undertaken to evaluate the association between red cell distribution width and glycemic control in patients with type 2 diabetes mellitus. The study also compared the distribution of RDW quartiles between controlled and uncontrolled diabetic patients, determined the association between elevated RDW quartiles and uncontrolled diabetes using odds ratio analysis, and described the age and sex distribution according to RDW quartiles and HbA1c categories.

Aim

To evaluate the association between RDW and glycemic control among patients with diabetes mellitus.

Objectives

1. To compare the distribution of RDW quartiles between controlled and uncontrolled diabetic patients.
2. To determine the association between elevated RDW quartiles and uncontrolled diabetes using odds ratio analysis.
3. To describe the age and sex distribution of diabetic patients according to RDW quartiles and HbA1c categories.

MATERIALS AND METHODS

This hospital-based case-control study was conducted in the Department of General Medicine at Government Medical College Hospital, Thiruvallur, over a period of three months from June 2024 to August 2024. The study included patients with type 2 diabetes mellitus attending the Master Health Check-up (MTM) outpatient department or admitted to the general medical wards during the study period.

Study Population

A total of 452 patients with confirmed type 2 diabetes mellitus were enrolled in the study. Based on glycemic control according to the American Diabetes Association (ADA) criteria, participants were divided into two groups. The case group comprised 226 patients with uncontrolled diabetes (HbA1c ≥7% in adults and ≥8% in geriatric patients), while the control group included 226 patients with controlled diabetes (HbA1c <7% in adults and <8% in geriatric patients).

Sample Size

A total of 452 patients were included in the study, comprising 226 patients with controlled diabetes and 226 patients with uncontrolled diabetes.

Inclusion and Exclusion Criteria

Patients aged 18 years and above with a confirmed diagnosis of type 2 diabetes mellitus who were willing to provide informed consent and attended the MTM outpatient department or were admitted to the general medical wards during the study period were included.

Patients with known haematological disorders such as anaemia or haemoglobinopathies, chronic kidney disease, chronic liver disease, or those receiving dialysis were excluded. Pregnant women, patients who had received vitamin B12, folic acid, or iron supplementation within the previous three months, individuals with a history of blood transfusion during the preceding three months, and those unwilling to provide informed consent were also excluded.

Methods

After obtaining informed consent, demographic and clinical details were recorded for all eligible participants. Following an overnight fast of at least 8 hours, venous blood samples were collected under aseptic precautions. Laboratory investigations included fasting blood sugar (FBS), postprandial blood sugar (PPBS), glycated hemoglobin (HbA1c), and RDW. All analyses were performed using fully automated hematology and biochemistry analyzers following standard laboratory procedures.

RDW was considered the primary haematological parameter for assessing anisocytosis and was categorized into three quartiles: Q1 (11.0–12.9%), Q2 (13.0–13.9%), and Q3 (>14.0%). The distribution of RDW quartiles was compared between controlled and uncontrolled diabetic patients.

Age and sex distribution according to RDW quartiles and HbA1c categories was assessed among the 226 patients with controlled diabetes. HbA1c categories were defined as HbA1c-1 (<7%), HbA1c-2 (7.0–8.9%), and HbA1c-3 (≥9.0%).

The primary outcome measure was the association between RDW quartiles and glycemic control. Secondary outcome measures included comparison of RDW quartile distribution between controlled and uncontrolled diabetic patients and assessment of age and sex distribution according to RDW quartiles and HbA1c categories.

Statistical Analysis

Data were entered into Microsoft Excel 2019 and analyzed using SPSS software version 21. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables

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were presented as frequency and percentage. Categorical variables were compared using the Chi-square test. Odds ratios (OR) with corresponding confidence intervals were calculated to assess the association between RDW quartiles and glycemic control. A p-value of <0.05 was considered statistically significant.

RESULTS

Of the 226 patients with controlled diabetes, 89 (39.4%) were in RDW quartile (Q1), 70 (31.0%) in Q2, and 67 (29.6%) in Q3. Among the 226 patients with uncontrolled diabetes, 68 (30.1%) were in Q1, 87 (38.5%) in Q2, and 71 (31.4%) in Q3 ($p < 0.05$). The odds ratios for uncontrolled diabetes were 1.6 for Q2 and 1.3 for Q3 compared with Q1. [Table 1]

Table 1: Distribution of RDW Quartiles and Association with Glycemic Control

RDW Quartile	RDW Range (%)	Controlled Diabetes	Uncontrolled Diabetes	Odds Ratio
Q1	11.0–12.9	89 (39.4%)	68 (30.1%)	Reference
Q2	13.0–13.9	70 (31.0%)	87 (38.5%)	1.6
Q3	>14.0	67 (29.6%)	71 (31.4%)	1.3

The mean age was 57.96 ± 0.67 years in Q1, 60.21 ± 0.90 years in Q2, and 57.71 ± 1.12 years in Q3. The numbers of males and females were 40 and 49 in Q1, 32 and 38 in Q2, and 30 and 37 in Q3. [Table 2]

Table 2: Age and Sex Distribution According to RDW Quartiles

RDW Quartile	Mean Age (years) ± SD	Males (n)	Females (n)
Q1	57.96 ± 0.67	40	49
Q2	60.21 ± 0.90	32	38
Q3	57.71 ± 1.12	30	37

The mean age was 58.84 ± 0.76 years in the HbA1c-1 group, 59.97 ± 0.83 years in the HbA1c-2 group, and 63.39 ± 1.17 years in the HbA1c-3 group. The numbers of males and females were 37 and 48 in HbA1c-1, 46 and 49 in HbA1c-2, and 19 and 27 in HbA1c-3. [Table 3]

Table 3: Age and Sex Distribution According to HbA1c Categories

HbA1c Category	Mean Age (years) ± SD	Males (n)	Females (n)
HbA1c-1	58.84 ± 0.76	37	48
HbA1c-2	59.97 ± 0.83	46	49
HbA1c-3	63.39 ± 1.17	19	27

DISCUSSION

Type 2 diabetes mellitus is associated with several hematological alterations, including changes in RDW, which may reflect glycemic status. The present study aimed to evaluate the association between RDW and glycemic control in patients with type 2 diabetes mellitus. Overall, higher RDW quartiles were associated with uncontrolled diabetes, while age and sex distributions varied across RDW quartiles and HbA1c categories.

In our study, the distribution of RDW quartiles differed between patients with controlled and uncontrolled diabetes. Higher RDW quartiles were associated with greater odds of uncontrolled glycemic status, and the difference in RDW distribution between the two groups was statistically significant. Similarly, Allahyani et al. reported significantly higher RDW values in patients with type 2 diabetes compared with healthy controls (15.2 ± 4.6% vs. 12.7 ± 0.6%; $p = 0.002$) and demonstrated a significant positive correlation between RDW and HbA1c, supporting the association between elevated RDW and poor glycemic control.[10] Likewise, Afzal et al. reported a statistically significant positive correlation between RDW and HbA1c among patients with type 2 diabetes mellitus ($r = 0.126$, $p = 0.024$), suggesting that higher RDW was associated with poorer glycemic control.[11] Similarly, Hassan et al. reported significantly higher RDW values in prediabetic individuals than in healthy controls (14.5% vs. 14.1%; $p = 0.003$), with higher RDW independently associated with prediabetes (AOR = 1.24, 95% CI: 1.01–1.53) and positively correlated with HbA1c ($r = 0.19$, $p = 0.006$).[12] These findings indicate that elevated RDW is consistently associated with worsening glycemic status and may serve as a readily available hematological marker reflecting impaired glycemic control in individuals with diabetes.

The present study demonstrated that the age and sex distribution varied across the RDW quartiles. Female participants were more frequently represented than males in each quartile, while the mean age showed variation among the RDW categories. Similarly, Jiang et al. evaluated 5,093 older adults according to RDW quartiles and reported significant differences in age and sex across the quartiles, with the mean age increasing from 69.7 ± 5.1 years in Q1 to 71.9 ± 5.8 years in Q4 ($p < 0.001$). The proportion of females also differed significantly across the quartiles, ranging from 60.7% in Q1 to 53.6% in Q4 ($p =$

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0.005).[13] Likewise, Yu et al. evaluated 427 patients with type 2 diabetes mellitus according to RAR quartiles and reported significant differences in age across the quartiles, with the median age ranging from 59 years in Q1 and Q2 to 63 years in Q3 (p = 0.007). However, unlike our findings, sex distribution did not differ significantly across the RAR quartiles, with male proportions ranging from 51.9% to 66.1% (p = 0.081).[14] These findings indicate that age consistently varies across RDW-related quartiles, whereas differences in sex distribution may depend on the study population, sample characteristics, and the hematological marker used for stratification.

Our findings showed that age and sex distribution differed across the HbA1c categories. Female participants predominated in all HbA1c groups, and the mean age increased across the categories, with the highest age observed in the group with the poorest glycemic control. Similarly, Iuliano et al. evaluated HbA1c according to age and sex in three independent cohorts of patients with type 2 diabetes mellitus (2012: n = 1249, 2017: n = 1125, and 2024: n = 1125) and reported that HbA1c patterns varied across age groups, whereas sex differences were minimal and inconsistent. The authors found no significant overall sex differences in HbA1c in 2012 (p = 0.466), 2017 (p = 0.246), or 2024 (p = 0.349), with a significant sex difference observed only among participants aged ≥80 years in 2017 (p = 0.025).[15] Likewise, Fu et al. reported significant differences in age and sex across RDW tertiles among 487 patients with latent autoimmune diabetes in adults, with females accounting for 52.8% of the study population and significant variation in age among the RDW tertiles (p < 0.05). They also observed that RDW was significantly associated with HbA1c in patients with high GAD titers after adjusted analysis.[16] These findings indicate that age is an important determinant of glycemic status, while sex-related differences are less consistent across diabetic populations, supporting the influence of demographic factors on glycemic control.

Limitations

The present study was conducted at a single tertiary care center over a relatively short study period, which may limit the generalizability of the findings. The case-control design did not allow the establishment of a causal relationship between RDW and glycemic control. In addition, the duration of diabetes and long-term follow-up were not assessed, limiting evaluation of their influence on RDW and future glycemic outcomes.

CONCLUSION

Red cell distribution width was significantly associated with glycemic control in patients with type 2 diabetes mellitus, with higher RDW quartiles observed among patients with uncontrolled diabetes. Variations in age and sex were also noted across RDW quartiles and HbA1c categories. RDW may serve as a simple, inexpensive, and readily available hematological marker for identifying patients with poor glycemic control.

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