Association Of Red Cell Distribution Width And Red Cell Distribution Width-Albumin Ratio With Peripheral Arterial Disease In Patients With Type 2 Diabetes Mellitus: A Cross-Sectional Study

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ABSTRACT

Background:
Peripheral arterial disease (PAD) is a common macrovascular complication of type 2 diabetes mellitus (T2DM) and is frequently underdiagnosed. Red cell distribution width (RDW) and red cell distribution width–albumin ratio (RAR) have emerged as potential laboratory markers of inflammation and cardiovascular risk. This study aimed to evaluate the association of RDW and RAR with ankle–brachial index (ABI) and to assess their diagnostic performance in detecting PAD among patients with T2DM.

Methods:
In this hospital-based cross-sectional study, 101 patients with T2DM were enrolled. PAD was assessed using ABI measured by Doppler ultrasonography, with ABI <0.9 defining PAD. RDW was obtained from automated hematology analysis, and serum albumin was measured using standard biochemical methods. RAR was calculated as RDW divided by serum albumin. Pearson's correlation, independent sample t-test, and receiver operating characteristic (ROC) curve analysis were performed.

Results:
Seventy-eight patients (77.2%) were classified as having PAD. RDW showed a significant inverse correlation with ABI ($r = –0.363$, $p = 0.0002$), while RAR demonstrated a stronger negative correlation ($r = –0.621$, $p <0.0001$). Mean RDW and RAR were significantly higher in the PAD group compared to the non-PAD group ($p <0.01$). ROC analysis revealed good discriminatory ability of RDW for identifying PAD (AUC = 0.79).

Conclusion:
RDW and RAR were significantly associated with ABI in patients with T2DM, with RAR demonstrating a stronger relationship with disease severity. These routinely available laboratory parameters may have adjunctive value in the risk stratification of PAD among diabetic patients.

Keywords: Diabetes Mellitus, Type 2; Peripheral Arterial Disease; Ankle-Brachial Index; Red Cell Distribution Width; Serum Albumin; Biomarkers.
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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is associated with an increased risk of macrovascular complications, including peripheral arterial disease (PAD). PAD in diabetic patients is frequently underdiagnosed due to its often asymptomatic nature, yet it significantly contributes to morbidity and risk of adverse cardiovascular outcomes [1,2]. The ankle-brachial index (ABI) is a simple and non-invasive method for detecting lower extremity arterial obstruction, with values <0.9 widely used to define PAD [3].

In recent years, increasing attention has been directed toward routinely available hematological and biochemical markers that may reflect underlying vascular inflammation and endothelial dysfunction . Red cell distribution width (RDW), a parameter automatically generated as part of a complete blood count, represents the variability in erythrocyte size [4]. Beyond its conventional role in the evaluation of anemia, elevated RDW has been associated with inflammatory states, oxidative stress, and cardiovascular disorders [4,5].

Serum albumin is another routinely measured laboratory parameter and is considered a negative acute-phase reactant [6,7]. Reduced albumin levels have been linked to systemic inflammation and vascular pathology [8]. The red cell distribution width-albumin ratio (RAR), a composite index derived from RDW and serum albumin, has recently emerged as a potential marker of inflammatory and cardiovascular risk [9–11].

However, the available evidence exploring the association of RDW and RAR with peripheral arterial disease is still limited, particularly among patients with type 2 diabetes mellitus. More importantly, there is a paucity of data from Indian populations, where the burden of T2DM and its vascular complications is considerably high. In this context, the potential role of these simple, routinely available laboratory parameters in the early identification of PAD deserves systematic evaluation.

Therefore, the present study was undertaken to examine the relationship of RDW and RDW-albumin ratio with

the ankle-brachial index and to assess their diagnostic performance in detecting peripheral arterial disease among patients with type 2 diabetes mellitus.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional study was conducted in the Department of Medicine At SRM Medical College & Hospital, a tertiary care teaching hospital, between [August 2024] and [August 2025]. The study included patients with established type 2 diabetes mellitus attending both outpatient and inpatient services during the study period.

Study Population

A total of 101 adult patients with previously diagnosed type 2 diabetes mellitus were consecutively enrolled. Eligible participants were screened according to predefined inclusion and exclusion criteria.

Inclusion Criteria

- Age ≥18 years
- Diagnosed cases of type 2 diabetes mellitus
- Willingness to provide written informed consent

Exclusion Criteria

- History of peripheral vascular intervention or limb amputation
- Presence of acute infection or inflammatory condition at the time of recruitment
- Chronic liver disease
- Known hematological disorders
- History of blood transfusion within the preceding three months

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of SRM Medical College & Hospital (Approval No: SRMIEC-ST0724-1420). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrolment.

Clinical Assessment

Demographic and clinical details were recorded using a structured case record form. The following variables were documented:

- Age
- Sex
- Duration of diabetes
- Smoking status
- Body mass index (BMI)
- Associated comorbid conditions

Assessment of Peripheral Arterial Disease

Peripheral arterial disease (PAD) was assessed using the ankle–brachial index (ABI), measured by Doppler ultrasonography.

ABI was calculated as:

$$ABI = \frac{\text{Systolic blood pressure at ankle}}{\text{Higher of the two brachial systolic pressures}}$$

ABI values were categorized as follows:

- Severe PAD: <0.4
- Moderate PAD: 0.4–0.69
- Mild PAD: 0.7–0.89
- Borderline: 0.9–0.99
- Normal: ≥1.0

For analytical purposes, PAD was defined as ABI <0.9.

Laboratory Measurements

Venous blood samples were collected under aseptic precautions. All laboratory analyses were performed in the central laboratory of the institution following standard internal quality control protocols.

Hematological Parameters

Red cell distribution width (RDW) was measured using an automated hematology analyzer and expressed as percentage (%).

Biochemical Parameters

Serum albumin levels were measured using standard automated biochemical methods and expressed in g/dL.

Calculation of Red Cell Distribution Width–Albumin Ratio

The red cell distribution width–albumin ratio (RAR) was calculated using the following formula:

$$RAR = \frac{RDW(\%)}{\text{Serum albumin (g/dL)}}$$

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using [SPSS version 25]. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. The relationship between RDW, RAR, and ABI was assessed using Pearson's correlation coefficient. Participants were categorized into two groups:

- PAD group (ABI <0.9)
- Non-PAD group (ABI ≥0.9)

Independent sample t-test was used to compare mean RDW and RAR values between the two groups.

Diagnostic Performance

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of RDW in predicting PAD. The area under the curve (AUC) was calculated.

A p-value <0.05 was considered statistically significant.

RESULTS

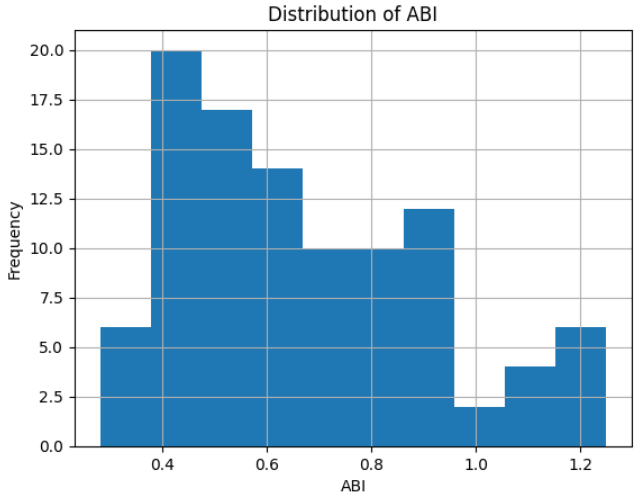
A total of 101 diabetic patients were included in the study.

Distribution of ABI

The distribution of ankle–brachial index (ABI) values

among study participants is shown in **Figure 1.** Most patients had ABI values between 0.4 and 0.8, with the highest frequency observed in the 0.4–0.6 range. Only a small proportion of patients had ABI ≥1.0, indicating normal arterial perfusion. A few patients had ABI values <0.4.

Figure 1. Distribution of ankle–brachial index (ABI) among study participants.



PAD Severity Distribution

The distribution of peripheral arterial disease (PAD) severity based on ABI values is presented in **Table 1.** Moderate PAD (ABI 0.4–0.69) was the most common category (n = 49), followed by mild PAD (ABI 0.7–0.89; n = 19) and severe PAD (ABI <0.4; n = 10). Eleven patients were classified as borderline (ABI 0.9–0.99), and 12 patients had normal ABI values (≥1.0).

When categorized using an ABI cut-off value of <0.9, 78 patients were classified as having PAD, whereas 23 patients were categorized as non-PAD, as shown in **Table2.**

Table 1. Distribution of peripheral arterial disease severity based on ankle–brachial index values.

Severity Category	Frequency
Moderate PAD (0.4–0.69)	49
Mild PAD (0.7–0.89)	19
Severe PAD (<0.4)	10
Borderline (0.9–0.99)	11
Normal (≥1.0)	12

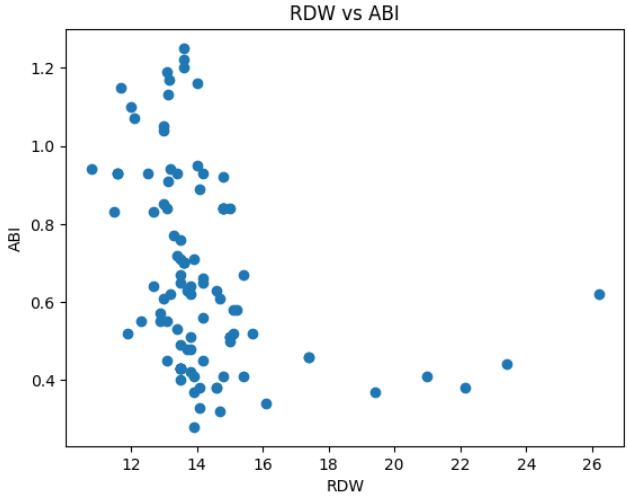
Table 2. Classification of study participants based on peripheral arterial disease status (ABI <0.9).

PAD Status	Frequency
PAD	78
No PAD	23

Association Between RDW and ABI

The relationship between red cell distribution width (RDW) and ABI is illustrated in **Figure 2**. A negative trend was observed, indicating lower ABI values with increasing RDW levels.

Figure 2. Scatter plot showing the relationship between red cell distribution width (RDW) and ankle–brachial index (ABI).



Correlation analysis demonstrated a statistically significant negative correlation between RDW and ABI ($r = –0.363$, $p = 0.0002$). A stronger negative correlation was observed between red cell distribution width–albumin ratio (RAR) and ABI ($r = –0.621$, $p < 0.0001$), as summarized in **Table 3.**

Table 3. Correlation analysis of red cell distribution width (RDW) and red cell distribution width–albumin ratio (RAR) with ankle–brachial index (ABI).

Variable	Correlation (r)	p-value
RDW vs ABI	–0.363	0.0002
RAR vs ABI	–0.621	<0.0001

Comparison Between PAD and Non-PAD Groups

Comparison of hematological parameters between PAD and non-PAD groups is shown in **Table 4.** The mean RDW was significantly higher in the PAD group compared to the non-PAD group (14.57 ± 2.37 vs. 12.90 ± 1.01; $p = 0.0015$). Similarly, mean RAR was significantly elevated in patients with PAD compared to those without PAD (4.25 ± 1.15 vs. 3.05 ± 0.15; $p < 0.0001$).

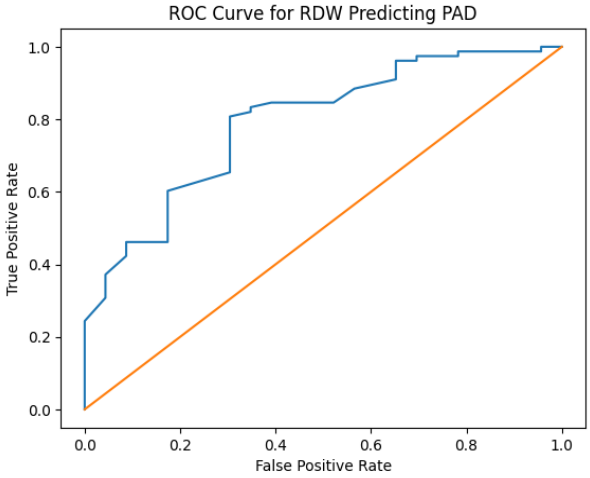
Table 4. Comparison of hematological parameters between peripheral arterial disease (PAD) and non-PAD groups.

Parameter	PAD (Mean ± SD)	No PAD (Mean ± SD)	p-value
RDW	14.57 ± 2.37	12.90 ± 1.01	0.0015
RAR	4.25 ± 1.15	3.05 ± 0.15	<0.0001

Diagnostic Performance of RDW

Receiver operating characteristic (ROC) curve analysis evaluating RDW for predicting PAD is shown in **Figure 3. The** area under the curve (AUC) was 0.79, indicating good discriminative ability of RDW in identifying PAD.

Figure 3. Receiver operating characteristic (ROC) curve of red cell distribution width (RDW) for predicting peripheral arterial disease (PAD).



DISCUSSION

In this study involving patients with type 2 diabetes mellitus, peripheral arterial disease was common and showed significant associations with routinely available laboratory parameters. Both red cell distribution width (RDW) and red cell distribution width-albumin ratio (RAR) demonstrated significant inverse correlations with ankle-brachial index (ABI). Notably, RAR exhibited a stronger negative correlation (r = –0.621) compared to RDW (r = –0.363), suggesting a closer relationship with the severity of arterial compromise. Receiver operating characteristic analysis further showed good discriminative ability of RDW for identifying PAD (AUC = 0.79).

Peripheral arterial disease in diabetes reflects chronic endothelial dysfunction, oxidative stress, and low-grade inflammation [12,13]. Serum albumin, a negative acute-phase reactant, decreases in inflammatory states and has been linked to endothelial dysfunction and atherosclerotic progression [9,13]. By integrating RDW and albumin into a composite index, RAR may better capture the combined effects of inflammation, oxidative stress, and nutritional status on vascular health [9]. The stronger correlation of RAR with ABI observed in this study suggests that this derived parameter may reflect vascular impairment more comprehensively than RDW alone.

The clinical relevance of these findings lies in the potential utility of RDW and RAR as adjunctive laboratory markers in patients with diabetes [4,14]. Both parameters are inexpensive, routinely available, and require no additional testing beyond standard hematological and biochemical evaluation. While RDW demonstrated good discriminatory performance (AUC = 0.79), these markers should not be considered diagnostic substitutes for ABI [15]. Rather, they may serve as supportive indicators prompting further vascular assessment in high-risk individuals.

Several limitations should be acknowledged. The cross-sectional design limits causal inference, and the study was conducted at a single center, which may affect generalizability. Although exclusion criteria were applied to minimize confounding, RDW and albumin levels may still be influenced by unmeasured inflammatory or nutritional factors [4,7]. Prospective multicenter studies are warranted to validate these findings and to evaluate the prognostic significance of RDW and RAR in predicting future vascular events.

In summary, RDW and RAR were significantly associated with ABI in patients with type 2 diabetes mellitus, with RAR demonstrating a stronger inverse correlation with disease severity. These findings highlight the potential role of routinely available laboratory indices in the risk stratification of peripheral arterial disease in diabetic patients.

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