# Relationship between Red Blood cell Distribution Width and Extent of Coronary Artery Disease in Patient with ST Elevation Myocardial Infarction

**Mai A. Hamza [a], Mohammed Mahmoud[a], Mahmoud Abd-el Ghaffar[a],Ahmed El-Tayeb[a]**
[a]Department of cardiology, Faculty of Medicine, Al-Azhar university (Assiut branch), Egypt

**Abstract**
**Background:** Coronary Artery Disease (CAD) is the leading cause of morbidity and mortality all around the world. Red cell distribution width (RDW) is an indicator for the variability and size of circulating erythrocytes, has recently been shown to be an independent predictor of prognosis in patients with cardiovascular disease.
**Objectives:** to assess the relationship between RDW and severity of coronary artery disease (CAD) by SYNTAX score in patients with ST-elevation myocardial infarction (STEMI) undergoing coronary angiography.
**Patients and methods:** Eighty consecutive patients, who underwent coronary angiography after diagnosis of STEMI, were enrolled in this study which was conducted at cardiology department of Qena university hospital and Qena general hospital at period from October 2018 to July 2019.
**Results:** there was no statistical significant difference **(p-value > 0.05)** between normal RDW patients and Abnormal RDW patients as regard demographic data(age, sex, BMI, smoking, HTN, dyslipidemia) except for DM, there was statistical significant difference, also there was no statistical significant difference **(p-value > 0.05)** between normal RDW patients and Abnormal RDW patients as regard laboratory data (eGFR,WBCs, neutrophils, lymphocytes, N/L ratio). While there was statistically significant difference **(p-value < 0.05)** between normal RDW patients and Abnormal RDW patients as regard LVEF, SWMA, number of affected vessels and SYNTAX score. After adjusting for all correlates, patients was high syntax scores were 3.6 times more liable for having abnormal RDW class (AOR=3.6, 95% CI: 1.2–7.3, p-value =0.029).
**Conclusion:** Red cell distribution width is positively correlated with number of diseased vessels and high syntax score and extent of coronary artery disease.
**Keywords:** ST-elevation myocardial infarction (STEMI), Red blood cell distribution width(RDW), SYNTAX score, atherosclerosis.

## Introduction

Acute Myocardial infarction (AMI) can be considered as a potential epidemic for mankind (**WHO, 1968**). It is the leading cause of death in North America and Europe. In 2007, coronary heart disease caused one out of every six deaths. The incidence and mortality with acute myocardial infarction has declined dramatically over the last 30 years, with the advent of coronary care unit, fibrinolytic therapy, catheter-based reperfusion, and statin therapy. The aging of population in advanced economies, as well as the global increased incidence of diabetes and obesity will however, increase the sequelae of atherosclerotic coronary artery disease in the future.(**Griffen P et al., 2013).**

The acute coronary syndrome includes unstable angina, non ST-segment elevation myocardial infarction (NSTEMI). Diabetes mellitus is one of the major risk factors of atherosclerosis (**Wilson, 2001**). Others being dyslipidaemia, smoking, gender, hypertention and family history of atherosclerotic arterial disease.Although atherosclerosis is a multifactorial process, inflammatory and immunological factors are considered to play critical roles (**Gitsioudis et al., 2014**). There have been many studies investigating the role of inflammatory and biochemical markers derived from complete blood count (CBC) in coronary artery disease (**Mayer et al., 2013**).
Red cell distribution width (RDW) is a measure of the variability in circulating

erythrocyte size that is often used in the differential diagnosis of anaemia (**Demir, 2002**).

Red cell distribution width (RDW) is widely accepted as a measure of anisocytosis and is routinely reported during automated complete blood counts (**SI et al., 2003**). It is commonly used to narrow the differential diagnosis of anaemia(**Mckenzie et al., 2003**).

The clinical significance of higher RDW has been considered in relation to cardiovascular disease (CVD), autoimmune disease and respiratory disease (**Aung et al., 2013**). The related mechanism is not fully understood. However, RDW is an indicator of inflammation related to early inflammatory biomarkers. Accordingly, systemic chronic inflammation leads to dysfunctional bone marrow with unsuccessful production of red blood cells (**Arbel et al., 2014**). As a result, it determines the migration of reticulocytes into the peripheral circulation, followed by an increase in circulating levels of immature red blood cells (RBCs), as well as in higher RDW levels (**Weiss et al., 2005**).

Many studies have reported that higher RDW values are associated with a worse prognosis and increased mortality rate in several cardiovascular diseases such as stable coronary artery disease, heart failure, and peripheral arterial disease and even in the unselected population (**Tonelli et al., 2008),** and also with poor TIMI flow following primary percutaneous coronary intervention (PCI) (**Karabulut et al., 2012**) and poor outcome of transcatheter aortic valve implantation (**Aung et al., 2013**). The RDW is also elevated in some subclinical states of atherosclerosis.The study aimed to evaluate the relationship between red cell distribution width and extent of coronary artery disease by SYNTAX score in patients with ST segment elevation myocardial infarction (STEMI).

## Patients and Methods

Eighty consecutive patients with ST segment elevation myocardial infarction were enrolled in this study which was conducted at cardiology department of Qena university hospital and Qena general hospital at period from October 2018 to July 2019.

Sample size calculation was carried out using G*Power 3 software. A calculated sample of 78 respondents was needed to detect an effect size of 0.2 in the mean SYNTAX score, with an error probability of 0.05 and 80% power on one-tailed test.

Informed consent was obtained from every patient after explanation of the procedure. Medical research and ethics committee approved the study.

### Inclusion criteria

Patients with ST elevation myocardial infarction based on the following (two or more criteria were used for the diagnosis):

1.Symptoms of ischemia (recent onset of typical ischemic chest pain).

2.Elevated serum cardiac biomarkers (serum troponin and CK-MB) consistent with acute MI.

3.ECG evidence of acute myocardial ischemia: ST segment elevation consistent with the clinical setting.

4.Angiographic evidence of acute thrombotic occlusion of the infarct-related artery at the time of coronary angiography.

5.Echocardiographic evidence of regional wall motion abnormality in the myocardial territory supplied by the infarct-related artery.

### Exclusion criteria

1. Patients with cardiogenic shock.
2. History of iron or vitamin deficiencies (such as folate or b12).
3. History of liver, renal, thyroid or autoimmune disease**.**
4. Acute or chronic infection**.**
5. Malignancy.
6. Valvular heart disease.

### Methods

**All patients were subjected to the following:**

**I-Full history taking**

That includes age, sex, risk factors for CAD including (smoking, hypertension, DM, dyslipidemia, positive family history of premature coronary artery disease and sudden cardiac death).

**A-Medical history:** of chronic disease and treatment, and drug intake.

**B- Presentation:** evaluation of chest pain**.**

**C-Evaluation of risk factor profile:** that include

1. Smoking
2. Diabetes mellitus
3. Hypertension
4. Dyslipidemia:
5. Family history of premature coronary artery disease.

**II-Electrocardiogram**

12. lead electrocardiogram diagnostic criteria of ST elevation myocardial infarction is ST segment elevation >0.2my at the J point in 2 or more contiguous, pericardial leads or adjacent limb lead in the standard 12lead electrocardiogram in addition to other diagnostic criteria which are typical prolonged chest pain >30 minutes and increase in serial serum marker of myocardium damage >2fold increase over the upper normal range required for creatinine kinase (CK) and troponin –I.

**III-Laboratory investigations**

Blood samples were drawn from each patient after their admission to the coronary care unit. Haemoglobin, white blood cell count, neutrophil ratio, lymphocyte ratio, and red cell distribution width (RDW) values were measured. Fasting blood glucose, serum creatinine were measured using conventional methods.

All the patients included were admitted to the coronary care unit and had thrombolytic theraby and full anti-ischemic measures.

**IV-Echocardiography**

Transthorathic echocardiography was done using a Vivid S5 GE to asses:

1. Over all LV systolic function using LVEF by M-mode.
2. Segmental wall motion abnormality

**V-Coronary angiography:**

Coronary angiography was performed using Philips machine (USA) under local anesthesia using Seldinger technique.

After introduction of Premedication as: sedatives, antibiotics, and anti-allergic medications, sterilization and local infiltration anesthesia of right groin, coronary angiography was done by right femoral approach using short femoral sheath (6F). Catheters used were JL (6F,4.0), JR (4.0-6F) diagnostic catheters. Contrast media used was Telebrex 350mg/ml. Hemostasis was done by manual compression immediately after the procedure.

Severity of coronary lesions assessed by SYNTAX score(SYNergy between PCI with TAXUS™ and CardiacSurgery). It is an angiographic tool grading the complexity of coronary lesions.SYNTAX score was designed to predict the postprocedural risk associated with PCI or surgical revascularization. Each coronary lesion producing a ≥ 50% luminal obstruction in vessels ≥ 1.5 mm was separately scored and added to provide the vessel SYNTAX score.The coronary tree is divided into 16 segments according to the AHA classification (Figure 1). Each segment is given a score of 1 or 2 based on the presence of disease and this score is then weighted based on a chart, with values ranging from 3.5 for the proximal left anterior descending artery (LAD) to 5.0 for left main, and 0.5 for smaller branches. The branches 3 months, a blunt stump, a bridging collateral image, the first segment visible beyond the total occlusion, and a side branch >1.5 diameter all receive one point. For trifurcations, one diseased segment gets three points, two diseased segments get four points, three diseased segments get five points, and four disease segments get six points. For bifurcation lesions, one point is given for types A, B, and C; two points are given for types D, E, F, and G; and one point is given for an angulation >70 degrees (Figure 2). Additionally, an aorto-ostial lesion is worth one point, severe tortuosity of vessel is worth two points, lesion length greater than 20 mm is worth one point, heavy calcification is worth 2 points, thrombus is worth 1 point, and diffuse disease or small vessel is at 1 point per segment involvement. For multiple lesions less than three reference vessel diameters apart, these are scored as a single lesion. However, at greater distance than three vessel diameters, these are considered separate lesions. The types of bifurcations are shown in Figure 2. Segments in which bifurcations are evaluated are those involving the proximal LAD and left main, the mid LAD, the proximal circumflex, mid circumflex, and crux of the right coronary artery. With regard

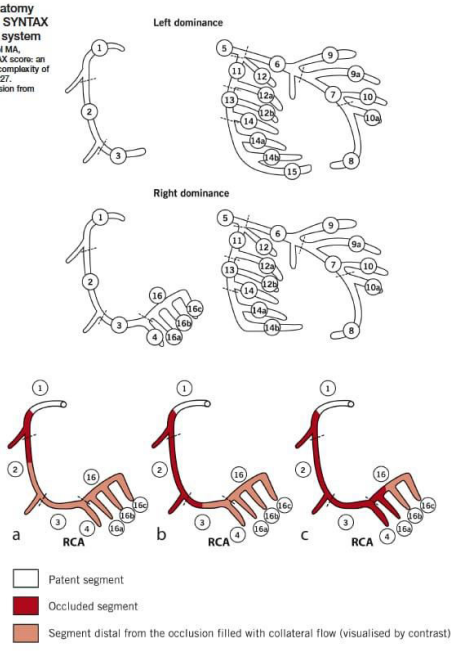
to trifurcation lesions, these also are additive in number of segments involved. The SYNTAX score algorithm then sums each of these features for a total SYNTAX score. Table 1 summarizes the SYNTAX grade categories. A computer algorithm is then queried and a summed value is produced.

TheSYNTAXscore was calculated using dedicated software that integrates thenumber of lesions with their specific weighting factors, based onthe amount of myocardium distal to the lesion according to thescore of Leaman et al.(**Leaman, et al 1981**) , and the morphological features of eachsingle lesion, as previously reported **(Sianos, et al 2005**).Using the openly accessible web based score calculator (http://www.syntaxscore.com) it is possible to calculate each patient's SYNTAX score by answering a series of questions about these lesions.

**Table 1. The SYNTAX score algorithm**

1. Dominance
2. Number of lesions
3. Segments involved per lesion, with lesion characteristics
4. Total occlusions with subtotal occlusions:
   a. Number of segments
   b. Age of total occlusions
   c. Blunt stumps
   d. Bridging collaterals
   e. First segment beyond occlusion visible by antegrade or retrograde filling
   f. Side branch involvement
5. Trifurcation, number of segments diseased
6. Bifurcation type and angulation
7. Aorto-ostial lesion
8. Severe tortuosity
9. Lesion length
10. Heavy calcification
11. Thrombus
12. Diffuse disease, with number of segments

Figure 1. Coronary anatomy segments used in the SYNTAX angiographic grading system
Reprinted from Sianos G, Morel MA, Kappetein AP, et al. The SYNTAX score: an angiographic tool grading the complexity of CAD. *EuroIntery* 2005; 1: 219-227. Copyright © 2009, with permission from Europa Edition.



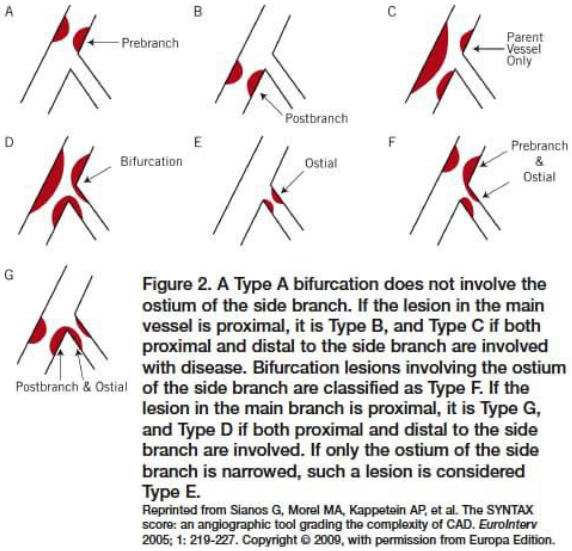




Figure 2. A Type A bifurcation does not involve the ostium of the side branch. If the lesion in the main vessel is proximal, it is Type B, and Type C if both proximal and distal to the side branch are involved with disease. Bifurcation lesions involving the ostium of the side branch are classified as Type F. If the lesion in the main branch is proximal, it is Type G, and Type D if both proximal and distal to the side branch are involved. If only the ostium of the side branch is narrowed, such a lesion is considered Type E.
Reprinted from Sianos G, Morel MA, Kappetein AP, et al. The SYNTAX score: an angiographic tool grading the complexity of CAD. *EuroInterv* 2005; 1: 219-227. Copyright © 2009, with permission from Europa Edition.

## Statistical analysis of data

Data were analyzed using Statistical Program for Social Science (SPSS) version 18.0. Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

## The following tests were done

Samples t-test of significance was used when comparingbetween two means.

- Chi-square ($x^2$) test ofsignificance was used to compareproportions.

Pearson's correlation coefficient (r) test was used for correlating data.. The clinical and demographic factors with proven statistical significance from the bivariate analyses were further included in the multivariable logistic regression models. A p-value equals or less than 0.05 was considered significant.

## Results

Our study was prospectively conducted in period between October 2018 and July 2019. It enrolled 80 patients presented with acute ST elevation myocardial infarction (STEMI) and admitted at Coronary Care Unit of Qena general Hospital and Qena University Hospital.

**Table (1): Description of demographic data, risk factors, laboratory data, echo and angiographic data of all studied patients.**

| Demographic data | | | Studied patients(N = 80) | |
|---|---|---|---|---|
| Demographic data | Age(years) | Mean ±SD | 56.7 ± 8.6 | |
| | | Min - Max | 38 – 80 | |
| | Sex | Male | 71 | 88.8% |
| | BMI | Mean ±SD | 27.01 ± 3.7 | |
| | | Min - Max | 19.8 – 35.2 | |
| Risk factors | | | Studied patients(N = 80) | |
| | Smoking | Yes | 43 | 53.5% |
| | DM | Yes | 42 | 52.5% |
| | HTN | Yes | 44 | 55% |
| | Dyslipidemia | Yes | 56 | 70% |
| laboratory data | | | Studied patients(N = 80) | |
| laboratory data | eGFR(ml/min/1.73 $m^2$) | Mean ±SD | 73.7 ± 15.7 | |
| | | Min – Max | 41 – 106 | |
| | WBCs (x $10^3$/cmm) | Mean ±SD | 8.06 ± 3.9 | |
| | | Min – Max | 4 – 20.3 | |
| | Neutrophils (%) | Mean ±SD | 61.8 ± 13.4 | |
| | | Min – Max | 28 – 85 | |
| | Lymphocytes (%) | Mean ±SD | 29.5 ± 12.6 | |
| | | Min – Max | 7.9 – 58 | |
| | RDW (%) | Mean ±SD | 13.7 ± 1.19 | |
| | | Min – Max | 10.1 – 17.8 | |
| | N/L ratio | Mean ±SD | 3.01 ± 2.6 | |
| | | Min – Max | 0.48 – 10.76 | |
| Echo data | | | Studied patients(N = 80) | |
| Echo data | LVEF (%) | Mean ±SD | 53.2 ± 6.26 | |
| | | Min - Max | 33 – 69 | |
| | SWMA | No | 30 | 37.5% |
| | | Yes | 50 | 62.5% |
| | Number of affected vessels | 1 vessel | 24 | 30% |
| | | 2 vessels | 34 | 42.5% |
| | | 3 vessels | 19 | 23.8% |
| | | 4 vessels | 3 | 3.8% |
| | SYNTAX Score | Mean ±SD | 22.6 ± 9.2 | |
| | | Min - Max | 8 – 43 | |

As regard the demographic data of all studied patients,the mean age of all studied patients was 56.7 ± 8.6 years with minimum age of 38 years and maximum age of 80 years. As

regard sex, there were 71 males (88.8%) and 9 females (11.3%) in the studied patients. As regard BMI, the mean BMI of all studied patients was 27.01 ± 3.7 with minimum BMI of 19.8 and maximum BMI of 35.2.

**As regard** laboratory data. **eGFR,** the mean eGFR of all studied patients was 73.7 ± 15.7 (ml/min/1.73 $m^2$)with minimum eGFR of 41 (ml/min/1.73 $m^2$) and maximum eGFR of 106 (ml/min/1.73 $m^2$). **As regard WBCs,** the mean WBCs of all studied patients was 8.06 ± 3.9 (x$10^3$/cmm) with minimum WBCs of 4 (x$10^3$/cmm) and maximum WBCs of 20.3 (x$10^3$/cmm). **As regard neutrophils,** the mean neutrophils of all studied patients were 61.8 ± 13.4 (%)with minimum neutrophils of 28 (%) and maximum neutrophils of 85 (%). **As regard lymphocytes,** the mean lymphocytes of all studied patients were 29.5 ± 12.6 (%)with minimum lymphocytes of 7.9 (%) and maximum lymphocytes of 58 (%). **As regard RDW,** the mean RDW of all studied patients was 13.7 ± 1.19 (%) with minimum RDW of 10.1 (%) and maximum RDW of 17.8 (%). **As regard N/L ratio,** the mean N/L ratio of all studied patients was 3.01 ± 2.6with minimum ratio of 0.48 and maximum ratio of 10.76.

**As regard echo and angiographic results,**the mean LVEF of all studied patients was 53.2 ± 6.26 (%)with minimum LVEF of 33 (%) and maximum LVEF of 69 (%). **As regard SWMA,** there were abnormalities in 50 patients (62.5%) of all studied patients. **As regard number of affected vessels,** 1 vessel was affected in 24 patients (30%), 2 vessels were affected in 34 patients (42.5%), 3 vessels were affected in 19 patients (23.8%) and 4 vessels were affected in 3 patients (3.8%). **As regard SS,** the mean SS of all studied patients was 22.6 ± 9.2with minimum SS of 8 and maximum SS of 43.

**Table 2. Correlation study between RDW and other studied parameters in studied patients.**

| Variables | (r) | p-value |
|---|---|---|
| **age** | - 0.11 | 0.307 NS |
| **BMI** | 0.064 | 0.517 NS |
| **eGFR** | 0.12 | 0.279 NS |
| **WBCs** | - 0.13 | 0.236 NS |
| **RDW vs Neutrophil** | - 0.107 | 0.346 NS |
| **RDW vsLymphocytes** | 0.102 | 0.367 NS |
| **RDW vs N/L ratio** | - 0.086 | 0.449 NS |
| **RDW vs LVEF** | **- 0.28** | **0.011 S** |
| **RDW vs Number of vessels** | **0.31** | **0.004 S** |
| **RDW vs SYNTAX Score** | **0.464** | **< 0.001 HS** |

**(r): Pearson correlation coefficient.**

**HS: p-value < 0.001 is considered highly significant.**

This table shows:

- Highly statistical significant **(p-value < 0.05)** Positive correlation **(r = 0.464)** between RDW and SS in studied patients.
- Statistically significant **(p-value < 0.05)** Negative correlation **(r = - 0.28)** between RDW and LVEF in studied patients.
- Statistically significant **(p-value < 0.05)** positive correlation **(r = 0.31)** between RDW and number of vessels in studied patients.
- No statistical significant **(p-value > 0.05)** correlation between RDW and other studied parameters in studied patients.

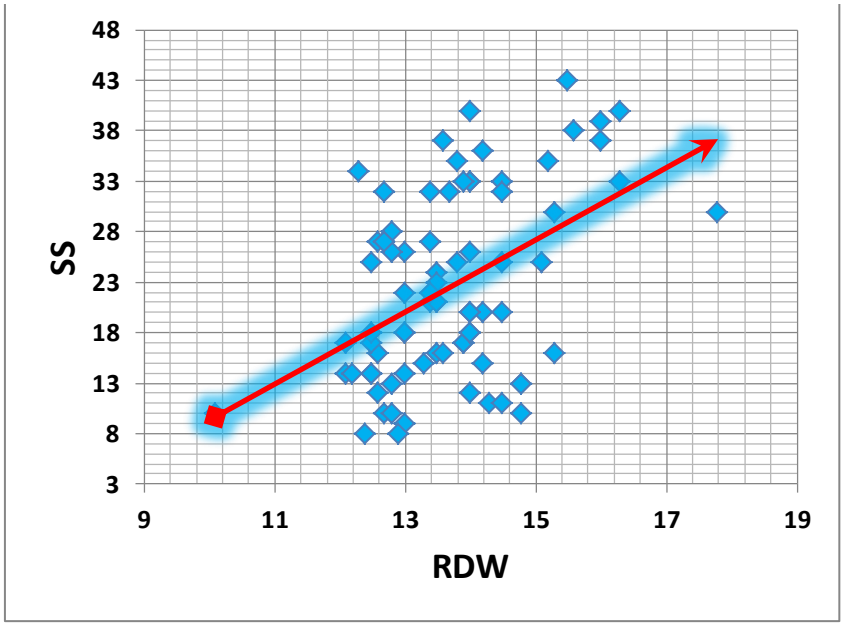



**Figure 3. Positive correlation between RDW and SS in studied patients.**

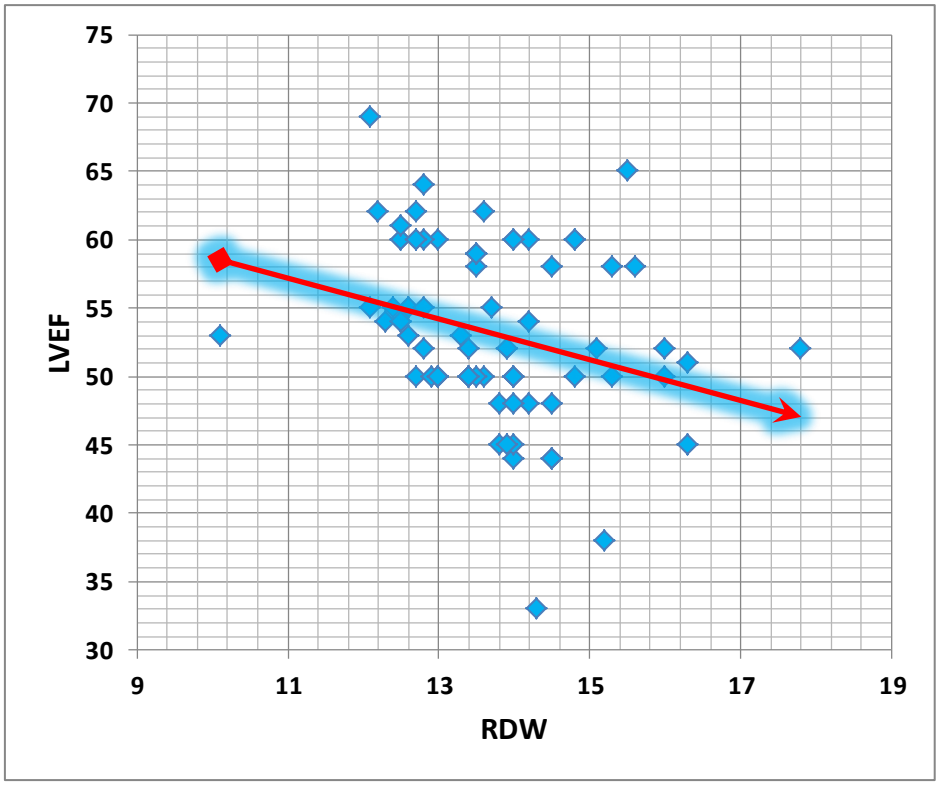



**Figure 4. Negative correlation between RDW and LVEF in studied patients.**

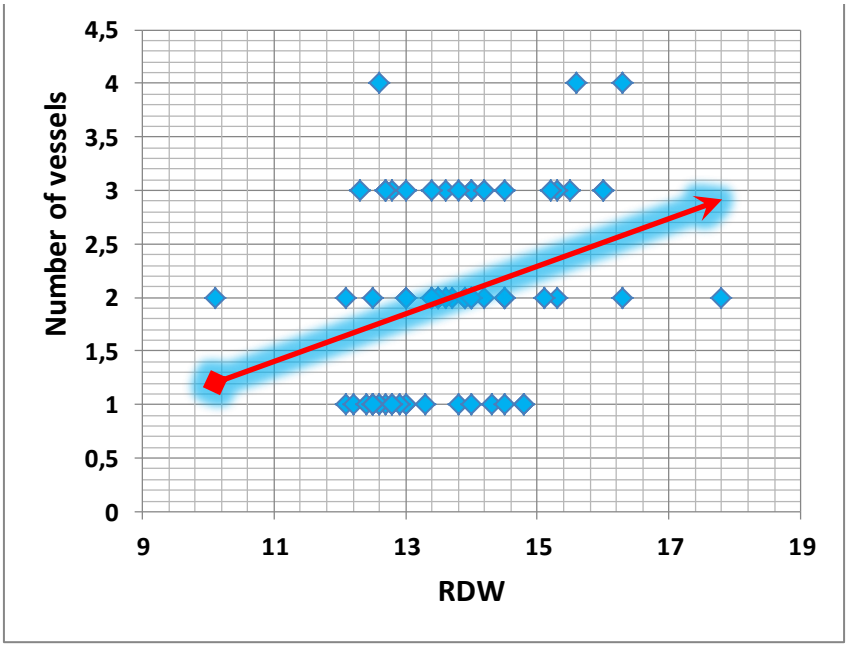



**Figure 5.Positive correlation between RDW and number of vessels in studied patients.**

**Table 3.Comparison of demographic data as regard RDW class.**

| Demographic data | | RDW Class | | | | Stat. test | P-value |
|---|---|---|---|---|---|---|---|
| | | Normal (n = 47) | | Abnormal (n = 33) | | | |
| Age(years) | Mean ±SD | 57.9 ± 7.7 | | 55.1 ± 9.5 | | T = 1.4 | 0.157 NS |
| Sex | Male | 41 | 87.2% | 30 | 90.9% | $X^2$ = 0.26 | 0.609 NS |
| | Female | 6 | 12.8% | 3 | 9.1% | | |
| Smoking | Non-smoker | 21 | 44.7% | 16 | 48.5% | $X^2$ = 0.11 | 0.737 NS |
| | Smoker | 26 | 55.3% | 17 | 51.5% | | |
| DM | No | 17 | 36.2% | 21 | 63.6% | **$X^2$ = 5.8** | **0.015 S** |
| | Yes | 30 | 63.8% | 12 | 36.4% | | |
| HTN | No | 20 | 42.6% | 16 | 48.5% | $X^2$ = 0.27 | 0.6 NS |
| | Yes | 27 | 57.4% | 17 | 51.5% | | |
| Dyslipidemia | No | 15 | 31.9% | 9 | 27.3% | $X^2$ = 0.19 | 0.656 NS |
| | Yes | 32 | 68.1% | 24 | 72.7% | | |
| BMI | Mean ±SD | 27.0 ± 3.9 | | 27.03 ± 3.3 | | T = 0.03 | 0.973 NS |

**T: independent sample T test.** **S: p-value < 0.05 is considered significant.**

**$X^2$: Chi-square test.** **NS: p-value > 0.05 is considered non-significant.**

This table shows no statistical significant difference **(p-value > 0.05)** between normal RDW patients and Abnormal RDW patients as regard demographic data except for DM, there was statistical significant difference.

**Table 4.Comparison of Echo data as regard RDW class**

| Echo | | RDW Class | | | | Stat. test | P-value |
|---|---|---|---|---|---|---|---|
| | | Normal (n = 47) | | Abnormal (n = 33) | | | |
| LVEF(%) | Mean ±SD | 52.9 ± 6.7 | | 48.8 ± 5.6 | | T = 2.9 | 0.004 S |
| SWMA | No | 17 | 36.2% | 20 | 60.6% | $X^2$ = 4.7 | 0.03 S |
| | Yes | 30 | 63.8% | 13 | 39.4% | | |
| Vessels affected | 1 vessel | 19 | 40.4% | 2 | 6.1% | $X^2$ = 14.5 | 0.002 S |
| | 2 vessels | 18 | 38.3% | 16 | 48.5% | | |
| | 3 vessels | 9 | 19.1% | 10 | 30.3% | | |
| | > 3 vessels | 1 | 2.1% | 5 | 15.2% | | |
| SYNTAX Score | Mean ±SD | 20.4 ± 8.03 | | 25.8 ± 9.9 | | T = 2.7 | 0.008 S |

**T: independent sample T test.** **S: p-value < 0.05 is considered significant.**

**$X^2$: Chi-square test.** **NS: p-value > 0.05 is considered non-significant.**

This table shows statistically significant difference **(p-value < 0.05)** between normal RDW patients and Abnormal RDW patients as regard LVEF, SWMA, number of affected vessels and SYNTAX score.

**Table5. Logistic regression model for the predictors of poor MBG**

| Factor | OR (95% CI) * | P value | AOR (95% CI) ** | P value |
|---|---|---|---|---|
| • **Age** | 1.02 (0.93 – 1.12) | =0.6 49 | 1.01 (0.98 – 1.04) | =0.614 |
| • **Sex (male)** | 4.35 (2.58 – 18.50) | **<0.001** | 8.43 (2.13 – 14.39) | **=0.018** |
| • **DM** | 7.19 (0.99 – 12.31) | =0.051 | 6.33 (1.66 – 14.18) | **=0.007** |
| • **BMI (Obese)** | 25.76 (1.31 – 58.21) | **=0.033** | 6.43 (3.16 – 13.07) | **=0.025** |
| • **LVEF%** | 1.04 (0.93 – 1.18) | =0.491 | 0.84 (0.45 – 2.87) | =0.269 |
| • **No. Affected vessel** | 1.83 (0.89 – 3.76) | =0.100 | 1.96 (1.10 – 3.48) | **=0.002** |
| • **SWMA** | 1.13 (0.75 – 3.28) | =0.875 | 1.15 (0.46 – 2.87) | =0.296 |
| • **SYNTAX (High)** | 2.79 (0.99 – 7.88) | =0.054 | 3.58 (1.14 – 7.25) | **=0.029** |

***OR (95% CI)=Unadjusted Odds Ratio (95% Confidence Interval)**
****AOR (95% CI)= Adjusted Odds Ratio (95% Confidence Interval)**

Table 5 showed the independent relationship between RDW classand syntax score among the studied cohort. After adjusting for all correlates, it was found that patients was high syntax scores were3.6 times more liable for having abnormal RDW class (AOR=3.6, 95% CI: 1.2–7.3, p-value =0.029) and this was statistically significant.

## Discussion

Our study demonstrated that out of 80 patients with ST elevation myocardial infarction included in the study, there was a positive association between high levels of red cell distribution width and the severity of coronary artery disease in those patients. We also demonstrated that high levels of RDW correlated with a high Syntax Score.

The RDW as a marker of the variability in erythrocyte volume is a routinely available component of the complete blood count. In patients with ineffective red cell production (such as iron deficiency, B12 or folate deficiency and hemoglobinopathies),

increased red cell destruction (such as hemolysis) and blood transfusion, the RDW levels can be elevated (**Förhécz et al., 2009**). The RDW reflects variability in the size of circulating red cells (anisocytosis) and is routinely reported by analyzers as part of routine complete blood counts.

Several studies showed an association between RDW and CAD, stable angina pectoris, unstable angina pectoris, and acute MI. However, the relation between RDW and complexity of CAD has been reported (**Isik et al., 2012**) in patients with stable angina pectoris; we showed this association in STEMI. In a prospective cross-sectional study which included 193 patients who underwent coronary angiography for stable CAD, **Isik et al**., found an association between RDW and presence, severity and complexity of CAD as determined using syntax score (**Isik et al., 2012**).

**Ephrem and Kanei**, in a retrospective study included 503 patients with UA or NSTEMI reported that elevated RDW is independently associated with higher recourse to CABG in patients presenting with UA or NSTEMI (**Ephrem et al., 2012**).

In agreement with our study, a large prospective cohort study conducted by**Ma et al**., and included 677 patients who underwent coronary angiography due to the presence of angina-like chest pain and/or positive treadmill stress test, and found that RDW is associated with both presence of CAD and the severity of coronary stenosis, suggesting that it might be a readily available marker for the prediction of CAD and its severity (**Ma et al., 2013).**

In agreement with our study, **Sahin et al**., reported in a prospective cross-sectional study that included 335 patients with NSTEMI; that RDW is a predictor of high SYNTAX score but is not associated with long-term mortality in patients with NSTEMI (**Sahinet al., 2015**).

In consistent with our study, **Nagula et al.,** enrolled 576 patients - who underwent coronary angiography after diagnosis of CAD or presence of angina like chest pain and/or positive treadmill test – in their study, and foud that RDW is an independent predictor of CAD and severity of coronary stenosis, suggesting that it can be a readily available marker for prediction and severity of CAD (**praveenNagula et al**.,**2017**).

**Uyarel et al.,** demonstrated that greater baseline RDW levels in patients with STEMI undergoing primary percutaneous coronary intervention were associated with increased risk of in-hospital, long-term cardiovascular mortality and longer hospital stay (**Uyarel et al., 2011**). The RDW has also been found to be an independent predictor of all-cause long-term mortality in patients with NSTEMI (**Azab et al., 2011**).

**Dabbah et al**., demonstrated a graded positive independent association between baseline and discharge RDW values and risk of all-cause mortality and development of new-onset heart failure in patients with AMI (**Dabbah et al., 2010**). Another study was done by **Wang et al**., demonstrated that high RDW was an independent predictor of re-infarction, heart failure and 1-month mortality in patients with ACS. Additionally, high RDW was associated with thrombus burden, poor reperfusion, in-hospital mortality and long-term mortality in patients with STEMI treated with PCI (**Wang et al., 2015**).

A study done by **Cavusoglu et al**., showed that RDW was a strong and independent predictor of mortality among an unselected population of males referred for coronary angiography. They also demonstrated that RDW was a powerful and independent predictor of mortality in the subpopulation of patients who had presented with acute coronary syndrome (**Cavusogluet al., 2009**).

Thus, our finding, although focusing among patients who underwent coronary angiography, strengthens the previous studies done on RDW as predictor of the prognosis of patients with myocardial infarction who undergo different interventions.

Our study demonstrated the relationship between high RDW levels and severity of CAD in STEMI patients.

As regarding number of diseased vessels, it was more with higher RDW levels in agreement with **Akin et al**., study that was done on 580 acute MI patients and show relation between high RDW and higher percentage of three vessel lesions in those patients(**Akin et al., 2013**).

As regarding the Syntax Score, the score was high in patients with higher RDW levels in agreement with **Akin et al., 2013** who found that RDW was associated with increased

severity of CAD assessed by Syntax score in AMI patients(**Akin et al., 2013**).

In agreement with our study, **Sahin et al.,** found that RDW is apredictor of high Syntax score **(Sahin et al., 2015).**

**ErhanTenekecioglu et al.,** included 251 patients with NSTEMI in their study and reported that A greater baseline red cell distribution width value was associated with myocardial injury and elevated cardiac troponin I levels in non-ST-elevation acute coronary syndrome. Therefore, the red cell distribution width could be considered for risk stratification of acute coronary syndrome patients admitted to emergency departments (**Tenekeciogluet al., 2015**). Another study was conducted on 60 patients presented for assessment of coronary artery disease (CAD) by coronary CT angiography and they were categorized into 2 groups, group (A) diabetics(30 patients),group(B) non-diabetics (30 patients) and reported that a greater baseline RDW (SD) value was independently associated with the presence of a greater coronary complexity of CAD and higher calcium score (**Onsyet al., 2017**). In agreement with our study results, another study was conducted by **AtacCeliket al.**, included 233 diabetic patients who underwent coronary angiography for CAD; and demonstrated that RDW was significantly higher in diabetic CAD patients (**Celiket al., 2017**). In a prospective study was conducted on a total of 470 STEMI patients who underwent primary PCI (which is deficient in our study with the follow up of complications), and demonstrated that RDW is an inexpensive and readily available biomarker that provides an additional level of risk stratification beyond that provided by conventional risk parameters in predicting long-term MACE and cardiovascular mortality in STEMI (**Pusurogluet al., 2015**). In contrast to our study, **Vaya et al**., demonstrated that RDW has also been found to be positively correlated with the neutrophil count in AMI patients (**Vaya et al., 2012**).

There are some limitations of our study, the small number of our patients, and this trial failed to consider the effects of serum iron and vitamin B12 on the RDW values. Also the RDW was assessed only once. We have no data on changes in RDW levels during the course of hospital stay and the deficient of follow up of our patients after discharge.

## Conclusion

Red cell distribution width is positively correlated with number of diseased vessels and high syntax score and extent of coronary artery disease.

## References

**Akın F, Köse N, Ayça B, Katkat F, Duran M, Uysal O. K, Arinc H. (2013).** Relation between red cell distribution width and severity of coronary artery disease in patients with acute myocardial infarction. Angiology, 64(8):592-596.

**Anderson KM, Wilson PW, Odell PM, KannelWB.(1991**).An updated coronary risk profile. A statement for health professionals.Circulation.83(1):356-62.

**Arbel Y, Shacham Y, Finkelstein A, Halkin A, Milwidsky A, Berliner S, Ziv-Baran T, Revivo M, Herz I, Keren G, Banai S.(2014).**Red blood cell distribution width (RDW) and long-term survival in patients with ST elevation myocardial infarction. Thrombosis research, 134(5):976-9.

**Aung N, Dworakowski R, Byrne J, Alcock E, Deshpande R, Rajagopal K, Brickham B, Monaghan MJ, Okonko DO, Wendler O, MacCarthy PA.(2013**). Progressive rise in red cell distribution width is associated with poor outcome after transcatheter aortic valve implantation. Heart,99(17):1261-6**.**

**Azab B, Torbey E, Hatoum H, Singh J, Khoueiry G, Bachir R, McGinnJrJT, McCord D, Lafferty J.(2011).** Usefulness of red cell distribution width in predicting all-cause long-term mortality after non-ST-elevation myocardial infarction.Cardiology. 119(2):72-80.

**Cavusoglu E, Chopra V, Gupta A, Battala VR, Poludasu S, Eng C, Marmur JD.(2009).** Relation between red blood cell distribution width (RDW) and all-cause mortality at two years in an unselected population referred for coronary

angiography. International Journal of Cardiology, 141(2):141-6.

**Celik A, Karayakali M, Altunkas F, Karaman K, Arisoy A, Ceyhan K, Kadi H, Koc F.(2017)**. Red cell distribution width is correlated with extensive coronary artery disease in patients with diabetes mellitus. Cardiovascular journal of Africa, 28(5):319.

**Dabbah S, Hammerman H, Markiewicz W, Aronson D.(2010).**Relation between red cell distribution width and clinical outcomes after acute myocardial infarction. The American journal of cardiology, 105(3):312-7.

**Demir A, Yarali N, Fisgin T, Duru F, Kara A.(2002).** Most reliable indices in differentiation between thalassemia trait and iron deficiency anemia. Pediatrics International, 44(6):612-6.

**Ephrem G;Kanei Y.(2012).**Elevated red blood cell distribution width is associated with higher recourse to coronary artery bypass graft. Cardiology, 123(3):135-41.

**Etter JF. (2004).** Associations between smoking prevalence, stages of change, cigarette consumption, and quit attempts across the United States.Preventive medicine, 38(3), 369-373**.**

**Förhécz Z, Gombos T, Borgulya G, Pozsonyi Z, Prohászka Z, Jánoskuti L.(2009).** Red cell distribution width in heart failure: prediction of clinical events and relationship with markers of ineffective erythropoiesis, inflammation, renal function, and nutritional state. American heart journal, 158(4):659-66.

**Gitsioudis G, Katus HA, Korosoglou G.(2014).**Assessment of coronary artery disease using coronary computed tomography angiography and biochemical markers. World journal of cardiology, 6(7):663.

**Griffin BP, Topol EJ, Nair D, Ashley K, editors.(2008).**Manual of cardiovascular medicine.Lippincott Williams & Wilkins.

**Isik T, Uyarel H, Tanboga IH, Kurt M, Ekinci M, Kaya A, Ayhan E, Ergelen M, Bayram E, Gibson CM.(2012).** Relation of red cell distribution width with the presence, severity, and complexity of coronary artery disease. Coronary artery disease, 23(1):51-6.

**Jung C, Fujita B, Lauten A, Kiehntopf M, Küthe F.(2011).**Red blood cell distribution width as useful tool to predict long-term mortality in patients with chronic heart failure. International journal of cardiology, 152(3):417-8.

**Karabulut A, Uyarel H, Uzunlar B, Çakmak M.(2012).** Elevated red cell distribution width level predicts worse postinterventional thrombolysis in myocardial infarction flow reflecting abnormal reperfusion in acute myocardial infarction treated with a primary coronary intervention. Coronary artery disease, 23(1):68-72.

**Leaman DM, Brower RW, Meester GT, Serruys P, Brand MVD. (1981).**Coronary artery atherosclerosis: severity ofthe disease, severity of angina pectoris andcompromised left ventricular function. Circulation, 63: 285–299.

**Ma FL, Li S, Li XL, Liu J, Qing P, Guo YL, Xu RX, Zhu CG, Jia YJ, Liu G, Dong Q.(2013).** Correlation of red cell distribution width with the severity of coronary artery disease: a large Chinese cohort study from a single center. Chinese medical journal, 126(6):1053-7.

**Mayer FJ, Gruenberger D, Schillinger M, Mannhalter C, Minar E, Koppensteiner R, Arbesú I, Niessner A, Hoke M.(2013).** Prognostic value of neutrophils in patients with asymptomatic carotid artery disease. Atherosclerosis, 231(2):274-80.

**McKenzie SD.(2003).**Introduction to anemia.Clinical Laboratory Hematology. Saddle River, NJ: Pearson Prentice-Hall. 161-88.

Nutritional anemias.Report of a **WHO scientific group (1986).**Health Organ Tech Rep ser 5:37-405.

**Onsy AM, Shehata MA, El Tawab AA, Khalil AE.(2017).** The Relation Between Red Cell Distribution Width (RDW) And Coronary Artery Calcium Score (CACS) in The Diabetic Patients Undergoing Coronary

CT Angiography. The Egyptian Journal of Hospital Medicine, 69(2):1838-48.

**Praveen Nagula; SuneethaK. (2017).**Correlation of red blood cell distribution width with the severity of coronary artery disease-A single center study.IHJ.

**Pusuroglu H, Cakmak HA, Akgul O, Erturk M, Surgit O, Akkaya E, Bulut U, Yildirim A.(2015).** The prognostic value of admission red cell distribution width-to-platelet ratio in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention.Revistaportuguesa de cardiologia, 34(10):597-606.

**Sahin O, Akpek M, Sarli B, Baktir AO, Savas G, Karadavut S, Elcik D, Saglam H, Kaya MG, Arinc H.(2015).** Association of red blood cell distribution width levels with severity of coronary artery disease in patients with non-ST elevation myocardial infarction. Medical Principles and Practice.24(2):178-83.

**Saudek CD, Herman WH, Sacks DB, Bergenstal RM, Edelman D, Davidson MB.(2008).** A new look at screening and diagnosing diabetes mellitus. The Journal of Clinical Endocrinology & Metabolism. 93(7):2447-53.

**Sianos G, Morel MA, Kappetein AP, Morice MC, Colombo A, Dawkins K et al.(2005).**TheSYNTAX Score: an angiographic tool gradingthe complexity of coronary artery disease. EuroIntervention, 1: 219–227.

**Sl P, Greer JP, Foerster J, Lukens JN.(2003).** Examination of blood and bone marrow.Wintrobe's Clinical Hematology 11th ed. Salt Lake City, UT: Lippincott Wilkins & Williams.5-25.

**Tenekecioglu E, Yilmaz M, Yontar OC, Bekler A, Peker T, Karaagac K, Ozluk OA, Agca FV, Kuzeytemiz M, Senturk M, Aslan B.(2015).** Red blood cell distribution width is associated with myocardial injury in non-ST-elevation acute coronary syndrome. Clinics,70(1):18-23.

**Tonelli M, Sacks F, Arnold M, Moye L, Davis B, Pfeffer M.(2008).**Cholesteroland Recurrent Events (CARE) Trial Investigators.Relation between red blood cell distribution width and cardiovascular event rate in people with coronary disease. Circulation, 117(2):163.

**Uyarel H, Ergelen M, Cicek G, Kaya MG, Ayhan E, Turkkan C, Yildirim E, Kirbas V, Onturk ET, Erer HB, Yesilcimen K.(2011).** Red cell distribution width as a novel prognostic marker in patients undergoing primary angioplasty for acute myocardial infarction. Coronary artery disease, 22(3):138-44.

**Vaya A, Hernández JL, Zorio E, Bautista D.(2012).** Association between red blood cell distribution width and the risk of future cardiovascular events. Clinical hemorheology and microcirculation, 50(3):221-5.

**Wang P, Wang Y, Li H, Wu Y, Chen H.(2014).** Relationship between the red blood cell distribution width and risk of acute myocardial infarction.Journal of atherosclerosis and thrombosis, 22(1):21-6.

**Weiss G;Goodnough LT.(2005).**Anemia of chronic disease. New England Journal of Medicine, 352(10):1011-23.

**Wilson PW.(2001).** Diabetes mellitus and coronary heart disease. Endocrinology and Metabolism Clinics, 30(4):857-81.