ARCHIVES OF THE TURKISH SOCIETY OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

# Hematological Incidies May Predict Oxidative Stress in Patients with ST-segment Elevation Myocardial Infarction

## Hemogram Indeksleri ST-segment Yükselmeli Myokart Enfarktüsü Hastalarında Oksidatif Stresi Öngörebilir

**ABSTRACT**

**Objective:** Oxidative stress is closely related to the development of atherosclerosis and acute coronary syndromes. In this study, we aimed to examine the relationship between hemogram indices and oxidative stress parameters in patients with ST-segment elevation myocardial infarction.

**Methods:** A single-centered, prospective, and cross-sectional study was performed in 61 patients with ST-segment elevation myocardial infarction. Before coronary angiography, in the blood samples taken from the peripheral vein, hemogram indices and oxidative stress parameters such as total oxidative status, total antioxidant status, and oxidative stress index were examined. We examined a total of 15 hemogram indices.

**Results:** Most of the study patients were male (78%), and the mean age was 59.3 ± 12.2 years. Mean corpuscular volume value was found to be negatively and moderately significantly correlated with total oxidative status and oxidative stress index values ($r=-0.438$, $r=-0.490$, $P < 0.001$). A negative and moderate significant correlation was found between mean corpuscular hemoglobin and total oxidative status and oxidative stress index values ($r=-0.487$, $r=-0.433$, $P < 0.001$). Red cell distribution width value was found to be positively and moderately correlated with total oxidative status ($r=0.537$, $P < 0.001$). Red cell distribution width was also found to be moderately and statistically significantly correlated with oxidative stress index value ($r=0.410$, $P=0.001$). In receiver operating characteristic analysis, mean corpuscular volume, mean corpuscular hemoglobin, and red cell distribution width levels have been successful in predicting total oxidative status and oxidative stress index.

**Conclusions:** We conclude that mean corpuscular volume, mean corpuscular hemoglobin, and red cell distribution width levels predict oxidative stress in patients with ST-segment elevation myocardial infarction.

**Keywords:** Acute coronary syndrome, hemogram, myocardial infarction, oxidative stress

**ÖZET**

**Amaç:** Oksidatif stress ateroskleroz ve akut koroner sendrom gelişimi ile yakından ilişkilidir. Bu çalışmada ST-segment yükselmeli miyokard enfarktüsü hastalarında hemogram indeksleri ile oksidatif stres parametreleri arasındaki ilişkiyi incelemeyi amaçladık.

**Yöntemler:** ST-segment yükselmeli miyokard enfarktüsü 61 hasta üzerinde yapılan çalışmamız tek merkezli, prospektif ve kesitseldi. Koroner anjiyografi öncesinde alınan peripheral ven kanından homegram indeksleri ve oksidatif stress parametrelei olan total oksidatif durum (TOS), total antioksidatif surum (TAS) ve oxidative stress indexi (OSI) incelendi. Toplam on beş hemogram indexi incelendi.

**Bulgular:** Çalışma hastalarının çoğu erkekti (%78) ve ortalama yaş 59,3 ± 12,2 idi. Ortalama korpüsküler hacim (MCV) değeri ile TOS ve OSI değerleri arasında negatif ve orta düzeyde anlamlı korelasyon saptandı ($r=-0,438$, $r=-0,490$, $P < 0,001$). Ortalama korpüsküler hemoglobin (MCH) ile TOS ve OSI değerleri arasında negatif ve orta derecede anlamlı bir korelasyon bulundu ($r=-0,487$, $r=-0,433$, $P < 0,001$). Kırmızı hücre dağılım genişliği (RDW) değeri TOS ile pozitif ve orta düzeyde korele olarak bulundu ($r=0,537$, $P < 0,001$). RDW ile OSI değeri arasında da orta düzeyde ve istatistiksel olarak anlamlı bir ilişkili bulundu ($r=0.410$, $P=0,001$). ROC analizinde MCV, MCH ve RDW değerlerinin TOS ve OSI değerlerini tahmin etmede başarılı olduğu bulunmuştur.

**Sonuç:** MCV, MCH ve RDW düzeylerinin ST-segment yükselmeli miyokard enfarktüslü hastalarda oksidatif stresi öngördüğü sonucuna vardık.

**Anahtar Kelimeler:** Akut koroner sendrom, hemogram, myocardial enfarktüs, oksidatif stress

**ORIGINAL ARTICLE**
KLİNİK ÇALIŞMA

**Belma Kalaycı**[1]
**Ayse Ceylan Hamamcıoğlu**[2]
**Süleyman Kalaycı**[3]

[1]*Department of Cardiology, Zonguldak Bulent Ecevit University, School of Medicine, Zonguldak, Türkiye*
[2]*Department of Biochemistry, Zonguldak Bulent Ecevit University, Faculty of Pharmacy, Zonguldak, Türkiye*
[3]*Department of Cardiology, Zonguldak Ataturk State Hospital, Zonguldak, Türkiye*

**Corresponding author**:
Belma Kalaycı
✉ drbelma@hotmail.com

**Received:** October 16, 2022
**Accepted:** November 21, 2022

**Cite this article as**: Kalaycı B, Ceylan Hamamcioglu A, Kalaycı S. Hematological incidies may predict oxidative stress in patients with ST-segment elevation myocardial infarction. *Turk Kardiyol Dern Ars.* 2023;51(3):196-201.

DOI:10.5543/tkda.2022.37011

ST-segment elevation myocardial infarction (STEMI) is one of the acute coronary syndromes and is characterized by complete occlusion of the coronary artery. Almost all acute coronary syndromes develop as a result of the rupture of the atherosclerotic plaque in the coronary artery, which is followed by thrombus formation.[1] Although there are many factors in the formation of plaque in atherosclerosis and rupture of this plaque, oxidative stress (OS) is one of the best known.[2] The deterioration of the balance between free radicals and antioxidants causes OS within the body.[3] It has been reported by many investigators that in several diseases, such as cancer, neurodegenerative diseases, and atherosclerosis, OS gradually increases.[2,3]

An insufficient amount of blood and oxygen transportation to the myocardium in the area supplied by the coronary artery causes the development of myocardial ischemia. Together with the enhancement of OS and platelet activity following ischemic injury, myocardial infarction is being developed and expanded with thrombogenesis and inflammatory response.[4] ST-segment elevation myocardial infarction, a clinical condition, occurs as a result of complete occlusion of the coronary artery.

In this study, OS was determined by the detection of total antioxidant status (TAS), total oxidant status (TOS), and oxidative stress index (OSI) values. The hypothesis of our study was whether a simpler and cheaper method could be used to predict OS in STEMI patients. For this purpose, we aimed to investigate whether hemogram indices we routinely use in STEMI patients could predict TAS, TOS, and OSI values.

## Materials and Methods

This study was approved by our university's Local Ethics Committee (decision no: 2019-175-16/10, date: 16.10.2019) and has followed the principles outlined in the Declaration of Helsinki for human investigations. In addition, informed consent has been obtained from the participants involved in this study.

### Participants and Study Design

This prospective, cross-sectional study was performed at our university hospital's cardiology polyclinic between October 2019 and December 2019. A total of 61 patients were included in the study who were diagnosed with acute STEMI and underwent urgent coronary angiography at our center. The patients with acute or chronic infection, malignancy, autoimmune disease, or who were pregnant, under steroid usage, breastfeeding, and under the age of 18 were excluded. Individuals who refused to participate in the study were also excluded.

ST-segment elevation myocardial infarction was defined as chest pain together with the detection of new or presumed new ST-segment elevation in ≥ 2 adjacent leads in 12-lead electrocardiography.[5] Emergency coronary angiography was performed to all patients in this group, and as a standard, acetylsalicylic acid, clopidogrel, or ticagrelor and heparin were given before angiography; also, if not contraindicated, beta-blockers, statins, and angiotensin-converting enzyme inhibitors were prescribed during hospitalization.

### Data Collection and Blood Sample Preparation

Demographic information, body mass index, systolic blood pressure (SBP), heart rate, presence of hypertension, hyperlipidemia and/or diabetes, smoking status, and the drugs being used were recorded for all patients involved in the study. Hypertension was defined if an individual had SBP ≥ 140 mmHg and/or diastolic BP (DBP) ≥ 90 mmHg in more than 2 measurements in the hospital, previously diagnosed as hypertensive or if an individual was under the usage of any antihypertensive medications. Hyperlipidemia was defined if an individual had serum triglyceride levels ≥ 200 mg/dL, low-density lipoprotein cholesterol levels ≥ 130 mg/dL, serum total cholesterol levels ≥ 240 mg/dL, previously diagnosed with hyperlipidemia, or if an individual was under the usage of lipid-lowering medication. Diabetes mellitus was defined as having fasting plasma glucose levels above 126 mg/dL in multiple measurements or if an individual was already diagnosed as diabetic, or if a person was under the usage of antidiabetic medications. Both the active smokers and ex-smokers were recorded as smokers in the study.

Blood samples of the study patients were taken from the antecubital veins during the preparation for coronary angiography and taken into biochemistry tubes containing $K_2$EDTA. Hemogram analysis was performed with LH 780 Analyzer (Beckman Coulter, Miami, USA). Hemogram parameters including hematocrit, hemoglobin, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV), mean platelet volume (MPV), platelet, plateletcrit, red blood cell (RBC), red cell distribution width (RDW), white blood cell, neutrophil count, lymphocyte count, monocyte count, neutrophil to lymphocyte ratio, and platelet to lymphocyte ratio were examined.

The blood samples were centrifuged at 3000 rpm for 10 minutes, and the sera were separated. Separated sera were stored in Eppendorf tubes at −80°C until OS parameters were measured.

### Total Antioxidant Status

Commercially available kits (Relassay, Turkey) were used to measure total antioxidant status (TAS) levels. The principle of the assay depends on discoloration of 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) by antioxidants present in the sera. The antioxidant content of the sample sera was measured at 660 nm by using spectrophotometer. The precision value of the assay was <3%. Total antioxidant status data were expressed as "mmol Trolox equivalent/liter."[6]

### Total Oxidant Status

Commercially available total oxidant status (TOS) kits (Relassay, Turkey) were used. The method is based on an oxidation reaction. The ferric ion produced from ferrous ion-o-dianisidine complex forms an orange complex with xylenol, and this complex can be measured spectrophotometrically. Hydrogen peroxide is being used for the calibration of the assay and data were expressed as "micromolar hydrogen peroxide equivalent/liter."[7]

### Oxidative Stress Index

Oxidative stress index (OSI) was defined in arbitrary units and calculated by dividing TOS (μmol $H_2O_2$ equivalent/L) to TAS (μmol Trolox equivalent/L) as was also suggested by Aycicek et al.[8]

### Statistical Analysis

Statistical Package for Social Sciences version 19.0 software was used for statistical analyses. Shapiro–Wilk test helped to understand if the data were distributed normally. Mean ± standard

deviation or median (minimum–maximum) values were used for continuous variables. For categorical variables, frequency or percentage was used where appropriate. Pearson Chi-square test helped to compare categorical variables. Independent samples *t* test or the Mann–Whitney *U* test were used to compare continuous variables for 2 groups. Spearman's correlation analysis was performed to determine the relationship between continuous variables. MedCalc 19.6.4 was used to calculate receiver operating characteristic (ROC) curves. The optimal cut-off values of MCV, MCH, and RDW as well as the identification of high OSI and TOS values were determined by ROC curves, and $P < 0.05$ was considered as statistically significant for all tests.

## Results

Demographic and clinical data of STEMI patients are shown in Table 1. The mean age of our patients was 59.3, and 78% were male. The kidney function tests, complete blood count, and OS parameters of our patients are shown in Table 2. Oxidative stress parameters of our patients were TAS: 1.25 [1.04-1.56] mmol/L, TOS: 21.8 [16.6-36.4] μmol/L, and OSI: 1.76 [1.31-2.70] AU.

The relationship between all blood count parameters and TAS, TOS, and OSI values was evaluated by correlation analysis as reported in Table 3. A negative, moderate, and significant correlation was found between MCV value and with both TOS and OSI values ($r=-0.438$, $r=-0.490$, $P < 0.001$). Mean corpuscular hemoglobin value was also found to be negative, moderate, and statistically significantly correlated to TOS and OSI values ($r=-0.487$, $r=-0.433$, $P < 0.001$). A positive and moderate correlation was detected between RDW value and TOS ($r=0.537$, $P <0.001$). Red cell distribution width was also found to be moderately and statistically significantly correlated with OSI value ($r=0.410$, $P=0.001$).

As a result of the literature review, plasma TOS levels of above 17.68 μmol/L and OSI value of above 1.77 AU were accepted as cut-off values.[9] The power of MCV, MCH, and RDW values to predict the determined TOS and OSI cut-off values was evaluated with ROC curve analysis as seen in Table 4.

We concluded that the MCV level of ≤85.7 fL had 42% sensitivity and 93% specificity in predicting TOS, and MCV level of ≤88.9 fL had 83% sensitivity and 61% specificity in predicting OSI (respectively, AUC: 0.718, 95% CI: 0.588-0.826, $P=0.002$ and AUC: 0.758, 95% CI: 0.631-0.859, $P < 0.001$). We also concluded that the MCH level ≤ 29.2 pg had 93% specificity and 62% sensitivity in predicting TOS, and ≤ 29.7 pg had 67% specificity and 83% sensitivity in predicting OSI (respectively, AUC: 0.773, 95% CI: 0.648-0.870, $P < 0.001$ and AUC: 0.758, 95% CI: 0.631-0.859, $P=0.001$) (see Figures 1 and 2). In addition

**Table 1. Demographic and Clinical Data of the Study Patients**

| Parameters | Patients (n=61) |
|---|---|
| Age, years[β] | 59.3 ± 12.2 |
| Male, n (%) | 48 (78) |
| Hypertension, n (%) | 24 (39.3) |
| Diabetes mellitus, n (%) | 19 (31.1) |
| Hyperlipidemia, n (%) | 35 (57.4) |
| Coronary artery disease history, n (%) | 9 (14.8) |
| Smoking, n (%) | 42 (68.9) |
| Body mass index (kg/m$^2$)[β] | 27.5 ± 4.8 |
| Admission heart rate (beats/min)[β] | 81 ± 15 |
| Systolic blood pressure (mmHg)[β] | 129 ± 22 |
| Drug use | |
| Statin, n (%) | 14 (23) |
| Diuretic, n (%) | 9 (14.8) |
| RAS blocker, n (%) | 21 (34) |
| Beta blocker, n (%) | 10 (16.4) |
| Alpha blocker, n (%) | 1 (1.6) |
| CCB, n (%) | 10 (16.4) |
| Combine antihypertensive, n (%) | 16 (26.2) |
| Antiplatelet, n (%) | 10 (16.4) |

[β]Data are expressed as mean ± SD or number (%).
CCB, calcium channel blocker; RAS, renin angiotensin system; STEMI, ST-segment elevation myocardial infarction.

**Table 2. Laboratory Findings of Study Population**

| Parameters | Patients (n=61) |
|---|---|
| Urea (mg/dL) | 35 [29.5-46.5] |
| Creatinin (mg/dL) | 0.9 [0.8-1.0] |
| TAS (mmol/L) | 1.25 [1.04-1.56] |
| TOS μmol/L | 21.8 [16.6-36.4] |
| OSI (AU) | 1.76 [1,31-2,70] |
| RBC (10$^6$/μL)[β] | 47 ± 0.6 |
| Hemoglobin (g/dL)[β] | 14 ± 1.9 |
| Hematocrit (%)[β] | 41.9 ± 5.3 |
| MCV (fL)[β] | 87.9 ± 5.4 |
| MCH (pg)[β] | 29.3 ± 2.3 |
| MCHC (g/dL) | 33.5 [32.8-33.8] |
| RDW (%) | 13.7 [13.2-14.9] |
| Platelet (10$^3$/μL)[β] | 248 ± 70 |
| MPV (fL)[β] | 9.2 ± 1.0 |
| Plateletcrit (%) | 0.21 [0.18-0.26] |
| WBC count (10$^3$/μL) | 10.5 [9.2-13.1] |
| Neutrophil count (10$^3$/μL) | 7.9 [6.2-9.3] |
| Lymphocyte count (10$^3$/μL) | 2.0 [1.5-2.7] |
| Monocyte count (10$^3$/μL) | 0.7 [06-0.95] |
| NLR | 3,8 [2.47-6.66] |
| PLR | 117 [87-176] |

[β]Data are expressed as mean ± standard deviation value, the other parameters expressed as median and 25th/75th interquartile range.
MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean corpuscular volume; MPV, mean platelet volume; NLR, neutrophil to lymphocyte ratio; OSI, oxidative stress index; PLR, platelet to lymphocyte ratio; RBC, red blood cell; RDW, red cell distribution width; TAS, total antioxidant status; TOS, total oxidant status; WBC, white blood cell.

**Table 3. Correlations Between Oxidative Stress Index and Complete Blood Count Parameters in Patients with ST-Segment Elevation Myocardial Infarction**

| | Oxidative Stress Marker | | | | | |
|---|---|---|---|---|---|---|
| | TAS | | TOS | | OSI | |
| **Variables** | ***r*** | ***P*** | ***r*** | ***P*** | ***r*** | ***P*** |
| RBC | 0.111 | 0.396 | 0.217 | 0.093 | 0.175 | 0.177 |
| Hemoglobin | 0.124 | 0.342 | 0.046 | 0.727 | 0.015 | 0.911 |
| Hematocrit | 0.158 | 0.225 | 0.091 | 0.488 | 0.024 | 0.856 |
| MCV | 0.130 | 0.318 | –0.438 | <0.001 | –0.490 | <0.001 |
| MCH | 0.98 | 0.450 | –0.487 | <0.001 | –0.433 | <0.001 |
| MCHC | –0.072 | 0.583 | –0.174 | 0.180 | –0.071 | 0.588 |
| RDW | 0.147 | 0.259 | 0.537 | <0.001 | 0.410 | 0.001 |
| Platelet | 0.078 | 0.552 | –0.088 | 0.499 | –0.104 | 0.425 |
| MPV | –0.246 | 0.056 | –0.185 | 0.154 | –0.028 | 0.831 |
| Plateletcrit | 0.001 | 0.992 | –0.160 | 0.218 | –0.125 | 0.338 |
| WBC | 0.111 | 0.395 | 0.040 | 0.762 | –0.066 | 0.613 |
| Neutrophil count | 0.150 | 0.249 | 0.070 | 0.593 | –0.057 | 0.661 |
| Lymphocyte count | –0.004 | 0.974 | –0.038 | 0.769 | 0.009 | 0.943 |
| Monocyte count | 0.032 | 0.804 | –0.174 | 0.179 | –0.230 | 0.075 |
| NLR | 0.121 | 0.355 | –0.073 | 0.575 | –0.073 | 0.575 |
| PLR | 0.102 | 0.436 | –0.085 | 0.517 | –0.085 | 0.517 |

MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean corpuscular volume; MPV, mean platelet volume; NLR, neutrophil to lymphocyte ratio; OSI, oxidative stress index; PLR, platelet to lymphocyte ratio; RBC, red blood cell; RDW, red cell distribution width; TAS, total antioxidant status; TOS, total oxidant status; WBC, white blood cell.

to this, RDW level of >13.4% can be used to predict TOS with 75% sensitivity and 62% specificity and to predict OSI with 86% sensitivity and 51% specificity (respectively, AUC: 0.728, 95% CI: 0.6599-0.834, $P=0.003$ and AUC: 0.700, 95% CI: 0.568-0.812, $P=0.003$).

## Discussion

In our study, MCV, MCH, and RDW values were found to be associated with TOS and OSI in STEMI patients. These were negatively and moderately correlated with MCV and MCH and positively and well correlated with RDW. In addition, it was concluded that MCV, MCH, and RDW predicted the cut-off values determined for TOS and OSI. MCH had the highest AUC value in the ROC curve analyses for prediction of TOS and OSI cut-off. We found no significant relationship between other hemogram indices and OS parameters.

Mean corpuscular volume is the measure of mean erythrocyte size and volume. It can be calculated by multiplying hematocrit percentage by 10 and dividing the result to the erythrocyte count. Mean corpuscular volume is closely related to erythrocyte-related disorders and helps to determine the type of anemia.[10,11] In an animal study with dogs having renal azotemia, OS parameters (red blood cell catalase activity, erythrocyte glutathione, and plasma malondialdehyde levels) were reported as being significantly related with low MCV values.[12] Similar results were also found in clinical studies. In patients with peripheral artery disease who underwent percutaneous intervention, low MCV levels were significantly associated with major adverse cardiovascular events (MACE).[13] In this study, the MCV cut-off value associated with adverse outcomes was defined as ≤ 90.8 Fl, and the hazard ratio was found as 2.662. In another study, conducted with hemodialysis patients, low MCV value was found to be associated with mortality.[14]

In a study performed with diabetic patients having STEMI, non-STEMI, or unstable angina, MCV was found to be unrelated with the MACE. However, high MCV was found to be associated with high MACE in the nondiabetic group.[15] In a study in which non-anemic acute coronary syndrome patients were included, high MCV was found to be associated with death and acute myocardial infarction.[16] Different results in terms of MCV level and mortality in different patient groups may be related to the co-morbid diseases of the patients or the prevalence of the disease.

Mean corpuscular hemoglobin is an anemia-related parameter that reflects the measurement of the average hemoglobin content of each red blood cell and is associated with iron metabolism. In type 1 diabetes mellitus patients, MCV and MCH values were found to be lower than those of healthy individuals. However, OS markers (plasma malondialdehyde levels and plasma nitric oxide levels) were found to be higher in the diabetic group.[17] In a study conducted with breast cancer patients, MCV, MCH, and MCHC levels were found to be lower and OS markers (2-diphenyl-1-picrylhydrazyl and malondialdehyde) were found to be higher in the patient group when compared to the control group.[18]

**Table 4. Hemogram Indices to Predict Determined TOS and OSI Values by ROC Curve Analysis**

| Variables | TOS (for >17.68 µmol/L) | OSI (for >1.77 AU) |
|---|---|---|
| MCV (fL) Cut off | ≤85.7 | ≤88.9 |
| Sensitivity (%) | 42.22 | 83.33 |
| Specificity (%) | 93.75 | 61.29 |
| AUC | 0.718 | 0.758 |
| 95% CI | 0.588-0.826 | 0.631-0.859 |
| *P* value | 0.002 | <0.001 |
| MCH (Pg) Cut off | ≤29.2 | ≤29.7 |
| Sensitivity (%) | 62.2 | 83.33 |
| Specificity (%) | 93.75 | 67.74 |
| AUC | 0.773 | 0.758 |
| 95% CI | 0.648-0.870 | 0.631-0.859 |
| *P* value | <0.001 | 0.001 |
| RDW (%) Cut off | >13.4 | >13.4 |
| Sensitivity (%) | 75.56 | 86.21 |
| Specificity (%) | 62.50 | 51.61 |
| AUC | 0.728 | 0.700 |
| 95% CI | 0.599-0.834 | 0.568-0.812 |
| *P* value | 0.003 | 0.003 |

AU, arbitrary units; AUC, area under the ROC curve; MCH, mean corpuscular hemoglobin; MCV, mean corpuscular volume; OSI, oxidative stress index; RDW, red cell distribution width; ROC, receiver operating characteristic; TOS, total oxidative status.

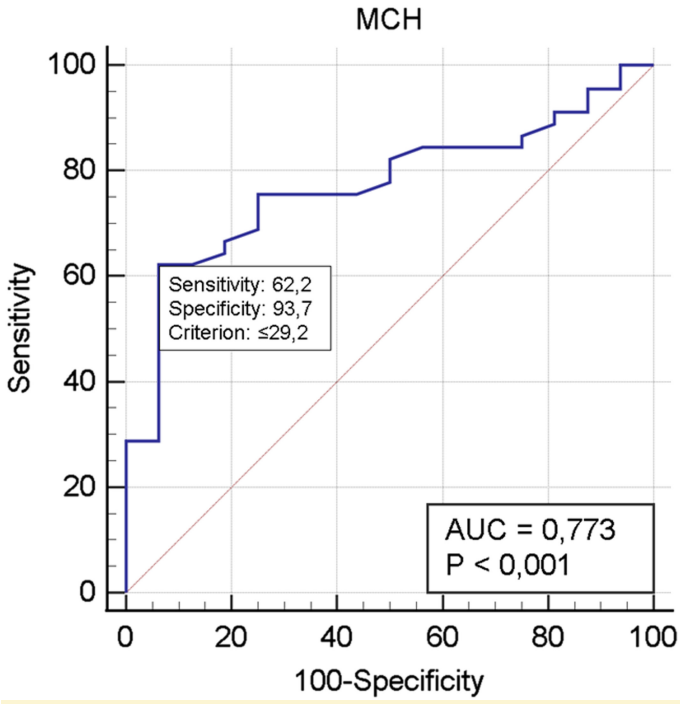


**Figure 1. The ROC curve analysis of the MCH level for the evaluation of determined TOS value (>17.68 µmol/L). MCH, mean corpuscular hemoglobin; ROC, receiver operating characteristic; TOS, total oxidant status.**

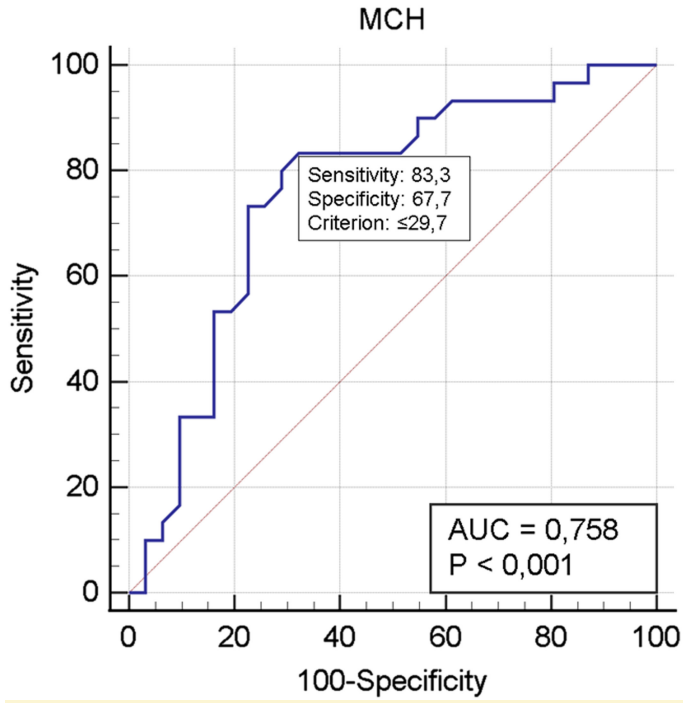


**Figure 2. The ROC curve analysis of the MCH level for the evaluation of determined OSI value (>1.77 AU). MCH, mean corpuscular hemoglobin; ROC, receiver operating characteristic; OSI, oxidative stress index.**

Erythrocytes are the major targets for reactive oxygen species (ROS) in the circulating blood, and they are being protected by antioxidants to complete their lifespan of more than 100 days. Due to the enhancement of OS within the body, erythrocyte membranes become $Ca^{2+}$ permeable, the enhancement of $Ca^{2+}$ ions within the cells activates $Ca^{2+}$-sensitive $K^{+}$ channels and the cells shrink. The whole procedure is known as eryptosis, a suicidal death of erythrocytes. The reason for eryptosis is to eliminate damaged erythrocytes, but in case of insufficient erythropoiesis within the body, anemia would be inevitable. In heart failure and atherosclerosis, eryptosis can be stimulated by many ROS-generating factors such as nitric oxide synthase, NAD(P)H oxidase, and xanthine oxidase.[19,20] Therefore, in this study, we also evaluated MCV, MCH, and RDW levels of STEMI patients, and to our knowledge, for the first time in literature, we concluded that low MCV and MCH and high RDW levels are associated with OS, and these hemogram indices can be used to predict OS in this patient group. It was reported previously in acute lymphoblastic leukemia child patients that the reduced MCV values are found in older erythrocytes due to decreased amount of RBC production.[21] In another study, RDW levels were found to be higher in patients with cardiovascular disease and obstructive sleep apnea syndrome.[22] An increased RDW is a reflection of abnormal RBC survival due to the deterioration of erythrocyte homeostasis which might be caused by several factors, including OS, dyslipidemia, and hypertension.[23] By trying to produce new red blood cells to compensate for this, reduction in erythrocyte volume and decrease in hemoglobin content is a possible and expected result. The increase in the variability of the shape of the circulating erythrocytes may also be due to a similar reason.

The relationship between hemogram indices and OS parameters has not been previously investigated in a study with STEMI patients. This aspect of our work will shed light on literature. However, our study has a small sample which is the main limitation of our study. Future studies with a larger sample size should be designed. The mean hemoglobin level of our patients was 14 ± 1.9 g/dL, and there were only 6 patients with a hemoglobin level of less than 12 g/dL. However, we did not differentiate the patients as anemic and non-anemic and did not test their iron levels. This was another limitation of our study. A more detailed study can be performed by making this distinction in a larger patient group. In addition, new risk-scoring systems can be developed by including these hemogram parameters in patient mortality and morbidity scores.

## Conclusions

Mean corpuscular volume, MCH, and RDW levels predict OS in STEMI patients. Complete blood count test to be applied in the emergency department is a simple, cheap, and easily accessible test. In this respect, we believe that more conclusions about oxidative status in STEMI patients could be reached with less cost.

**Ethics Committee Approval:** Ethical committee approval was received from the Ethics Committee of Zonguldak Bulent Ecevit University (Approval No:2019-175-16/10, date: 16.10.2019).

**Informed Consent:** Written informed consent was obtained from the patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Design – B.K., A.C.H.; Data Collection and/or Processing – B.K., S.K.; Analysis and/or Interpretation – B.K., S.K.; Writing – B.K., A.C.H.,S.K.; Literature Review – S.K.

**Acknowledgments:** The authors would like to thank Füruzan Köktürk (PhD) and Çınar Severcan (PhD) for their help in statistical analysis.

**Declaration of Interests:** The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding:** This work was supported by Scientific Research Projects Unit of University [BAP 2019-21664500-01] in Turkey.

## References

1. Naghavi M, Libby P, Falk E, et al. From vulnerable plaque to vulnerable patient: a call for new definitions and risk assessment strategies: Part I. *Circulation*. 2003;108(14):1664-1672. [CrossRef]
2. Madamanchi NR, Vendrov A, Runge MS. Oxidative stress and vascular disease. *Arterioscler Thromb Vasc Biol*. 2005;25(1):29-38. [CrossRef]
3. Cui H, Kong Y, Zhang H. Oxidative stress, mitochondrial dysfunction, and aging. *J Signal Transduct*. 2012;2012:646354. [CrossRef]
4. Fuentes E, Moore-Carrasco R, de Andrade Paes AM, Trostchansky A. Role of platelet activation and oxidative stress in the evolution of myocardial infarction. *J Cardiovasc Pharmacol Ther*. 2019;24(6):509-520. [CrossRef]
5. Thygesen K, Alpert JS, Jaffe AS, et al. Fourth universal definition of myocardial infarction (2018). *J Am Coll Cardiol*. 2018;72(18):2231-2264. [CrossRef]
6. Erel O. A novel automated direct measurement method for total antioxidant capacity using a new generation, more stable ABTS radical cation. *Clin Biochem*. 2004;37(4):277-285. [CrossRef]
7. Erel O. A new automated colorimetric method for measuring total oxidant status. *Clin Biochem*. 2005;38(12):1103-1111. [CrossRef]
8. Aycicek A, Erel O, Kocyigit A. Decreased total antioxidant capacity and increased oxidative stress in passive smoker infants and their mothers. *Pediatr Int*. 2005;47(6):635-639. [CrossRef]
9. Menteşe U, Turan I, Usta S, et al. Systemic oxidant/antioxidant balance in human abdominal aortic aneurysm. *Perfusion*. 2016;31(4):288-294. [CrossRef]
10. Maner BS, Moosavi L. *Mean Corpuscular Volume. StatPearls*. Treasure Island (FL): StatPearls Publishing LLC; 2021.
11. Tefferi A. Anemia in adults: a contemporary approach to diagnosis. *Mayo Clin Proc*. 2003;78(10):1274-1280. [CrossRef]
12. Buranakarl C, Trisiriroj M, Pondeenana S, Tungjitpeanpong T, Jarutakanon P, Penchome R. Relationships between oxidative stress markers and red blood cell characteristics in renal azotemic dogs. *Res Vet Sci*. 2009;86(2):309-313. [CrossRef]
13. Tscharre M, Lee S, Kopp CW, Panzer S, Gremmel T. Mean corpuscular volume predicts adverse outcomes following peripheral angioplasty with stenting and is associated with on-treatment platelet reactivity. *Angiology*. 2021;72(1):16-23. [CrossRef]
14. Honda H, Kimachi M, Kurita N, Joki N, Nangaku M. Low rather than high mean corpuscular volume is associated with mortality in Japanese patients under hemodialysis. *Sci Rep*. 2020;10(1):15663. [CrossRef]
15. Cheng L, Zhang L, Liu J, et al. Prognostic value of admission mean corpuscular volume for major adverse cardiovascular events following stent implantation in nondiabetic and diabetic patients with acute coronary syndrome. *Dis Markers*. 2020;2020:7054596. [CrossRef]
16. Franczuk P, Kaczorowski M, Kucharska K, et al. Could an analysis of mean corpuscular volume help to improve risk stratification in non-anemic patients with acute myocardial infarction? *Cardiol J*. 2015;22(4):421-427. [CrossRef]
17. Abdel-Moneim A, Zanaty MI, El-Sayed A, Khalil RG, Rahman HA. Relation between oxidative stress and hematologic abnormalities in children with type 1 diabetes. *Can J Diabetes*. 2020;44(3):222-228. [CrossRef]
18. Rajizadeh A, Mozaffari-Khosravi H, Zavar-Reza J, Shiryazdi SM. Comparison of hematological parameters, iron levels, and oxidative stress in women with and without breast cancer: A case- control study. *Med J Islam Repub Iran*. 2017;31:114. [CrossRef]
19. Bissinger R, Bhuyan AAM, Qadri SM, Lang F. Oxidative stress, eryptosis and anemia: a pivotal mechanistic nexus in systemic diseases. *FEBS Journal*. 2019;286(5):826-854. [CrossRef]
20. Semba RD, Patel KV, Ferrucci L, et al. Serum antioxidants and inflammation predict red cell distribution width in older women: the Women's Health and Aging Study I. *Clin Nutr*. 2010 October;29(5):600-604. [CrossRef]
21. Small T, Oski FA. The mean corpuscular volume (MCV) in children with acute lymphoblastic leukemia. *Clin Pediatr (Phila)*. 1979;18(11):687-688, 690-691. [CrossRef]
22. Saygin M, Ozturk O, Ozguner MF, Akkaya A, Varol E. Hematological parameters as predictors of cardiovascular disease in obstructive sleep apnea syndrome patients. *Angiology*. 2016;67(5):461-470. [CrossRef]
23. Salvagno GL, Sanchis-Gomar F, Picanza A, Lippi G. Red blood cell distribution width: A simple parameter with multiple clinical applications. *Crit Rev Clin Lab Sci*. 2015;52(2):86-105. [CrossRef]