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Original Article

The relationship between infarct-related arteries patency with c-reactive protein/albumin ratio before primary percutaneous coronary intervention in patients with st-segment elevation myocardial infarction

St elevasyonlu miyokard enfarktüslü hastalarda enfarktüsle ilişkili arter açıklığı ile primer perkütan koroner girişim öncesi c-reaktif protein/albümin oranı arasındaki ilişki

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ABSTRACT

Aim: Inflammatory markers such as C-reactive protein and Albumin have previously been associated with poor prognosis in ST-elevation myocardial infarction (STEMI). The present study aims to investigate the relationship between the infarct-related arteries (IRA) patency and C-reactive protein/Albumin ratio (CAR) before primary percutaneous coronary intervention (p-PCI) in patients with STEMI.

Material and Methods: A total of 822 patients who underwent p-PCI for acute STEMI were included in this study. Patients were divided into two groups according to IRA patency as TIMI flow 0-1 (n = 551) and TIMI flow 2-3 (n = 271). CAR ratio measured at admission was compared with IRA patency.

Results: The average age of 822 patients was 55±12, and 84.3% (693) of the patients were male. The mean CAR level of the patients was determined as 0.26 (0.08-0.48). CAR level was statistically significantly higher in TIMI flow 0-1 group when compared to TIMI flow 2-3 group [0.31 (0.09-0.51) vs 0.23 (0.06-0.42); p<0.001]. In the multivariate logistic regression analysis a significant relation was found between CAR (odds ratio [OR]:1.56, 95% confidence interval [CI]:1.22-1.97, p<0.001), and neutrophil count (OR:1.72, 95% CI:1.33-2.25, p<0.001) in patients with TIMI flow 0-1

Conclusion: An inflammation-based risk index, CAR measured at admission in patients with anterior STEMI has been found to be a useful prognostic tool for predicting adverse cardiovascular outcomes. However, this finding needs to be confirmed in future prospective studies.

Keywords: C-reactive protein/albumin ratio, infarct-related arteries, ST-elevation myocardial infarction

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ÖZ

Amaç: C-reaktif protein ve Albumin gibi inflamatuar markerlar STEM'de daha önce kötü prognoz ile ilşkilendirilmiştir. Çalışmamızda ST elevasyonlu miyokard enfarktüsü (STEMI) geçiren hastalarda pirmer Perkütan Girişim (p-PKG) öncesi enfarktüsten sorumlu koroner arter açıklığı ile C-reaktif protein/Albumin oranı (CAR) arasındaki ilişkiyi araştırmayı amaçladık.

Gereç ve Yöntem: STEMI nedeni ile p-PKG uygulanmış 822 hasta çalışmaya dahil edildi. Hastalar IRA açıklığına göre TIMI akım 0-1 (n=551) ve TIMI akım 2-3 (n=271) olarak iki gruba ayrıldı. Başvuru sırasında ölçülen CAR oranı, IRA açıklığı ile karşılaştırıldı.

Bulgular: 822 hastanın yaş ortalaması 55±12' di ve %84,3 (693)' ü erkekti. Tüm çalışma hastalarının ortalama CAR düzeyi 0.26 (0.08-0.48) olarak tespit edildi. CAR düzeyi TIMI akım 0-1 grubunda TIMI akım 2-3 grubuna göre istatiksel anlamlılıkla daha yüksek bulundu [0.31 (0.09-0.51) vs 0.23 (0.06-0.42); p<0.001]. Yapılan multivariete lojistik regresyon analizinde CAR (odds ratio [OR]:1.56, 95% confidence interval [CI]:1.22-1.97, p<0.001) ve nötrofil sayısı (OR:1.72, 95% CI:1.33-2.25, p<0,001) TIMI 0-1 akım ile arasında anlamlı ilişki saptanmıştır.

Sonuç: Anterior STEMI hastalarında başvuru sırasında ölçülen inflamasyona dayalı bir risk indeksi olan CAR, olumsuz kardiyovasküler sonuçları tahmin etmek için yararlı bir prognostik araç olduğu bulunmuştur. Bununla birlikte, bu bulgunun gelecekteki prospektif çalışmalarda doğrulanması gerekmektedir.

Anahtar Kelimeler: C-reaktif protein/albümin oranı, İnfaktüsten sorumlu koroner arter açıklığı, ST elevasyonlu miyokard infarktüsü

Introduction

Although a decrease is seen in the mortality rate with the widespread of primary percutaneous coronary intervention (p-PCI) in patients with ST-elevation myocardial infarction (STEMI), there is still a high rate of mortality [1]. The rapid and successful revascularization of the infarct-related artery (IRA) has proven to be the most effective treatment option in patients with STEMI and improves clinical outcomes. IRA patency before p-PCI cause the short duration of ischemia in STEMI patients, thus decreasing complications such as infarction-related heart failure, cardiogenic shock and mortality, and high procedure success [2].

The use of inflammatory biomarkers has been increasing in the diagnosis and screening of atherosclerotic heart disease (AHD) [3]. Among the most frequently used biomarkers for this purpose, C-reactive protein (CRP) and albumin are known to have a strong association with individual AHD formation and presentation forms [4,5]. C-reactive protein/Albumin ratio (CAR) reflects the stability of albumin and CRP levels in the body. It has been shown to reflect the inflammatory status and prognosis better than the hs-CRP or albumin alone in critical patients, acute medical conditions, and cancer patients [6-9].

Detection of IRA patency in p-PCI in patients with STEMI provides predicting mortality and morbidity rates of the patients [10]. Therefore, in the present study, it was aimed to investigate the relationship between IRA patency before p-PCI and CAR in patients with STEMI.

Material and Methods

Patients with STEMI who underwent Primary PCI (p-PCI) in our hospital between February 2014 and December 2017 were included in this retrospective study. Inclusion criteria were as follows: onset of symptoms <6 hours before p-PCI; ST-segment elevation > 0.2 mV in 2 or more contiguous precordial or extremity leads. Left and right coronary angiograms were obtained before the attempted angioplasty. Exclusion criteria were venous graft-related infarcts, non-gradable IRA flow due to technical reasons, concurrent pericardial disease, chronic pulmonary disease, pulmonary hypertension, valvular heart disease (moderate to severe insufficiency and/or stenosis), acute pulmonary embolism, history of cardiac arrest before admission Patients with a history of the previous CAD treated with PCI or coronary artery bypass grafting, malignancy, active infection, and connective tissue disorder were excluded from the study. The patients were divided into two as TIMI 0-1 and TIMI 2-3 according to the IRA patency rate. Of the patients included in this study, 67% were of TIMI flow 0-1 (n = 551), 33% of TIMI flow 2-3 (n=271). Informed consent of each subject's approval of the Local Ethics Committee with the principles of the Helsinki Declaration was obtained.

Coronary Angiography

Coronary angiography (CAG) was performed within 90 minutes of hospital admission. All patients received dual antiplatelet therapy with aspirin (300 mg) and clopidogrel (600 mg) or ticagrelor (180 mg) loading dose before CAG. Preprocedural anticoagulation consisted of intravenous unfractionated

heparin (70 IU/kg) in all cases. Coronary angiograms were recorded to digital media for quantitative analysis (DICOM viewer, MedCom GmbH, Darmstadt, Germany). Digital angiograms were evaluated by 2 experienced cardiologists who were blinded to other patient information. In case of any conflicts regarding the assessments, an agreement was reached by consensus. The degree of coronary flow before PCI was classified by thrombolysis in myocardial infarction (TIMI) grade flow as assessed by the investigators. Patients with TIMI grade 2 or 3 flow in the IRA were considered to have a patent vessel. Primary PCI with stent implantation was performed according to current guidelines. The purpose of the p-PCI procedure was to obtain residual stenosis of <20% in IRA by visual evaluation. An optimal angiographic result was defined as the presence of TIMI grade 3 flow in the IRA following p-PCI. An unsuccessful procedure was defined as a procedure resulting in TIMI grade 0-1. Use of glycoprotein IIb/IIIa inhibitors (i.e. tirofiban) was left to the discretion of the attending physician. Complete ST-segment resolution was defined as a reduction of >70% in the summed 12-lead extent of ST-segment elevation from baseline to the post-procedural electrocardiogram, which was recorded at 90th minute after the first balloon inflation.

Laboratory Measurements

Routine complete blood cell count and blood evaluations for determining the blood glucose, creatinine, albumin, CRP, and troponin I levels were conducted using the admission blood samples. Troponin I levels was measured every 6 hours until they peaked. The albumin and CRP levels were measured using a Roche Diagnostics Cobas 8000 c502 analyzer (Indianapolis, USA). The CAR was calculated as the ratio of CRP to the albumin level multiplied by 100. The estimated glomerular filtration rate (eGFR) was calculated using the Cockcroft-Gault equation. Left ventricular ejection fraction (LVEF) was measured using the modified Simpson method.

Statistical Analyses

Data were analyzed using the SPSS 24.0 version (SPSS Inc, Chicago, Illinois). Normality of the data was determined using the Kolmogorov-Smirnov test. The continuous variables with a normal distribution are presented as mean + standard deviation (SD) values, while those without a normal distribution are presented as median and interquartile range values. Frequency distribution was calculated for the categorical variables (numbers and percentages). The continuous variables of the 2 groups were compared using the Student t-test or the Mann-Whitney U test. Categorical data were compared using the chi-square test or the Fisher exact test. Multivariate logistic regression analysis was used to determine independent predictors of coronary patency using variables found to be significant in univariate analysis (P <0.05). Receiver–operating characteristic (ROC) analyses were used to compare the performance power of the CAR, CRP, and albumin for coronary patency. The predictive validities were quantified as the area under the ROC curves (c statistics), and the comparisons of statistics were performed by De long's test.

Results

A total of 822 patients who underwent p-PCI due to STEMI and have IRA patency rates were included in the study. The average age of 822 patients was 55±12, and 84.3% (693) of the patients were male. The mean CAR level of all study patients was 0.26 (0.08-0.48). The patients were divided into two as TIMI 0-1 and TIMI 2-3 according to the IRA patency rate. Of the patients included in this study, 67% were of TIMI flow 0-1 (n = 551), 33% of TIMI flow 2-3 (n=271).

The baseline demographic, clinical, laboratory and angiographic characteristic features of the study patients according to TIMI flow are listed in Table 1. CAR level was found statistically significantly higher In the TIMI flow 0-1 group compared to TIMI flow 2-3 group [0.31 (0.09-0.51) vs 0.23 (0.06-0.42); p<0.001]. In the TIMI flow 0-1 group, there were statistically significant decreases in hemoglobin, platelet count, albumin level, e-GFR, and left ventricular EF, while there were significant increases in neutrophil count, C-reactive protein, lymphocyte count and heart rate when compared to TIMI 2-3 group (Table 1).

The univariate logistic regression analysis revealed that the CAR, hemoglobin, platelet count, albumin level, eGFR, left ventricular EF, neutrophil count, lymphocyte count, and heart rate values were associated with the IRA patency. CRP was not included in the analysis because it showed multicollinearity with CAR. In the multivariate logistic regression analysis to determine the relationship with IRA patency in patients with STEMI, the CAR (odds ratio [OR]:1.56, 95% confidence interval [CI]:1.22-1.97, p<0.001) and neutrophil count (OR:1.72, 95% CI:1.33-2.25, p<0.001) were found to be associated with TIMI 0-1 flow (Table 2).

In the ROC analysis performed to predict TIMI flow 0-1, the optimal predictive value for CAR was 0.375 with 48% sensitivity and 84% specificity. The ROC curves were compared to evaluate whether CAR has additional distinctive value on the CRP and albumin levels. CAR's Area Under Curve (AUC) value was statistically significantly higher compared to CRP (AUC: 0.59; 95%CI: 0.55-0.63, p=0.014) and albumin (AUC: 0.57; 95%CI: 0.53-0.62, p=0.028) in predicting TIMI flow 0-1 (Figure 1).

Table 1. Baseline Demographic, Clinical, Laboratory and Angiographic characteristic of study patients				
		Baseline IRA patency		
	All patients (n=822)	TIMI 0-1 (n=551)	TIMI 2-3 (n=271)	p value
Age [year]	55±12	54±11	56±12	0.76
Male gender [n (%)]	693 (84.3)	466 (84.6)	227 (83.8)	0.47
Diabetes mellitus [n (%)]	179 (21.8)	124 (22.5)	55 (20.3)	0.06
Hypertension [n (%)]	320 (38.9)	202 (36.7)	118 (43.5)	0.31
Hyperlipidemia [n (%)]	234 (28.4)	153 (27.7)	80 (29.5)	0.55
Smoking [n (%)]	295 (35.8)	209 (37.9)	86 (31.7)	0.25
Family history of CAD [n (%)]	186 (22.6)	128 (23.2)	58 (21.6)	0.11
KILLIP class >1 on admission	103 (12.5)	78 (14.2)	25 (9.2)	0.30
Systolic blood pressure [mmHg]	135±21	136±22	133±20	0.43
Heart rate [/min]	86±18	92±16	76±15	0.02
Hemoglobin [g/dl]	12.9±1.7	12.1±1.8	14.0±1.5	0.01
White blood cell count [103/µl]	12.0±3.3	12.4±3.4	11.2±3.0	0.74
Platelet count [105/µl]	259±68	255±74	271±58	<0.001
Neutrophil count [103/µl]	9.2±3.2	9.7±3.3	8.2±2.8	<0.001
Lymphocyte count [103/µl]	1.8±1.3	1.9±1.5	1.7±1.2	<0.001
Neutrphil to Lymphocyte ratio	4.9 (3.2-7.4)	5.1 (3.6-8.2)	4.7 (2.9-6.1)	0.13
Fasting blood glucose [mg/dl]	148.2±72.2	151.2±76.3	142.2±62.5	0.27
Estimated GFR [mL/min]	91.6±23.5	90.8±24.2	93.5±25.1	<0.001
C-reactive protein [mg/dl]	0.86 (0.51-1.36)	0.92 (0.59-1.55)	0.76 (0.45-1.36)	<0.001
Albumin [g/dl]	3.8 (3.6-4.1)	3.7 (3.5-4.0)	3.9 (3.6-4.1)	<0.001
CAR [x100]	22 (8-46)	26(9-49)	17(6-42)	<0.001
LVEF [%]	48.5±7.2	47.3±8.1	50.9±6.7	0.01
Total ischemia time (min)	169(108-245)	176(116-255)	145(92-228)	0.32
IRA [n (%)]				0,62
LAD [n (%)]	419 (51.0)	275 (50.0)	144 (53.1)	
LCX [n (%)]	110 (13.4)	74 (13.4)	36 (13.3)	
RCA [n (%)]	282 (34.3)	193 (35.0)	89 (32.8)	
Other coronary arteries [n (%)]	11 (1.3)	9 (1.6)	2 (0.7)	
Number of diseased vessel[n (%)]				0.12
1 vessel [n (%)]	513 (62.4)	334 (60.6)	179 (66.1)	
2-3 vessel [n (%)]	309 (37.6)	217 (39,4)	70 (33.9	

Data are expressed as mean ± SD for normaly distributed data or count (percentage) for categorical va-riables; CAD, Coronary artery disease; CAR, C-reactive protein to albumin ratio; eGFR, estimated glomerular filtration rate; IRA, Infarct releated artery; LAD, Left anterior descending artery; LVEF, left ventricular ejection fraction; LCX, Left circumflex artery; RCA, right coronary artery; TIMI, Thrombolysis in myocardial infarction

Table 2 . Univariate and multivariate logistic regression analysis for baseline IRA patency (TIMI 0/1)						
Variable	Univarite			Multivariate		
	Unadjusted OR	95 % CI	pvalue	Adjusted OR	95% CI	pvalue
Albumin	1.45	0.95-1.57	0.05			
eGFR	0.94	0.74-1.03	0.04			
Lymphocyte	1.25	1.08-1.45	0.02			
Neutrophil	1.83	1.28-2.34	<0.001	1.72	1.33-2.25	<0.001
Platelet	1.49	0.91-1.78	0.08			
Hemoglobin	1.38	0.89-1.42	0.12			
Heart rate	1.07	0.92-1.21	0.74			
CAR	1.80	1.21-2.41	<0.001	1.56	1.22-1.97	<0.001

CI=confidence interval; OR=oddsratio; CAD, Coronary artery disease; CAR, C-reactive protein to albumin ratio; eGFR, estimated glomerular filtration rate; IRA, Infarct releated artery

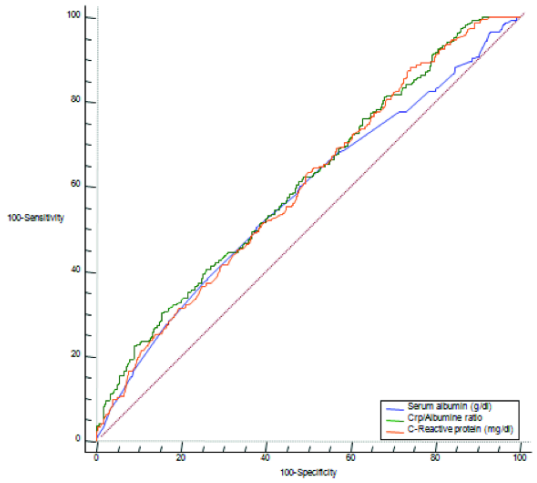

Figure 1. The receiver operating characteristic (ROC) curve comparison of C-reactive protein (CRP), albumin, and C-reactive protein to albumin ratio (CAR) in the prediction of baseline IRA patency

Discussion

To the best of our knowledge, this is the first study evaluating the relationship between the ratio of CAR with patency of IRA in patients with STEMI before the p-PCI. It revealed that CAR might be related to the IRA patency before p-PCI ($p<0.001$).

p-PCI is the gold standard treatment method in patients with STEMI. However, the duration of infarction is the most important factor affecting the clinical results of the patients [11]. In the HORIZON-AMI study, early IRA patency in patients with STEMI undergoing primary PCI is associated with better TIMI flow and myocardial blush post PCI and is an independent predictor of lower one-year mortality [12]. Christopoulos C et al. associated the IRA patency in patients with STEMI with increased endogenous thrombolysis, decreased platelet activity, and resulting decreased ischemia time [13]. Shortness of ischemia duration, decreased complications such as heart failure due to infarction, malignant arrhythmia, cardiogenic shock, mortality, and high procedure success in patients with STEMI [2]. Our study, in accordance with other studies, with statistical significance in the TIMI 0-1 group compared to the TIMI 2-3 group; There was a decrease in eGFR and left ventricular EF, and an increase in heart rate, which was associated with poor cardiovascular results (Table 1).

Inflammation plays an important role in determining both pathogenesis and prognosis in STEMI [14,15]. Management of the occurring systemic inflammatory process affects the prognosis of the disease [16]. Macrophage activation, free radical release and proinflammatory cytokines secreted from inflammatory cells increase in acute myocardial infarction [17]. Inflammation in STEMI causes an increase not only in the responsible plaque region but also in all systemic circulation and other plaques [18]. Besides, thrombus load in IRA creates microvascular plugs and causes no-reflow to increase the ischemic process and thus increases myocardial inflammation. As a result, an increase in inflammatory cells is seen in STEMI as an indicator of plaque inflammation as well as myocardial tissue destruction in the coronary arteries [19]. In the study by Pietila et al., it was found that the height of inflammatory markers showed the amount of destroyed myocardial tissue in patients who could not achieve IRA patency by giving thrombolytics [20,21]. In our study, consistent with previous studies, a decrease in the inflammatory marker albumin level and an increase in the number of neutrophils, C-reactive protein and lymphocytes were found (Table 1). Data investigating the relationship of IRA patency in patients with STEMI is limited. Doganay B. et al., who investigated IRA patency in patients with STEMI, have found a significant relationship between the co-peptit level and the IRA [22], while Jing L. et al., however, found a significant relationship between the homocysteine level and IRA [23]. CAR, an inflammatory marker, reflects the stability of albumin and CRP levels within the body. Few studies have reported the relationship between ACS and CAR. In studies performed, high CAR elevation was associated with poor prognosis in patients with STEMI and stable angina pectoris [24,25]. In a study investigating the relationship between short-term major adverse cardiac events (MACE) and CAR, which included 652 ACS patients, it was seen that increased CAR increased the likelihood of developing MACE [26]. Another study has revealed that CAR could predict no-reflow in patients with ST-elevation myocardial infarction [27]. In our study, the value of CAR was found to be statistically higher in patients without IRA patency in patient with STEMI (Table 1).

In patients with STEMI, the IRA patency, which is well known for its effects on major cardiac side effects and mortality, results in a decreased duration of ischemia and necrotic area, and associated inflammation in the ischemic area [28,29]. However, this effect in the IRA patency is limited with the thrombus load. Because the increased thrombus load in the IRA patency will disrupt coronary perfusion after p-PCI with microvascular obstruction. Insufficient perfusion will lead to increased ischemic area and associated inflammation. Considering that using the parameters reflecting the inflammatory process in patients with ACS in determining

thrombus load in the IRA patency will be useful for determining the prognosis of the patients, the relationship between IRA patency and CAR was investigated in patients with STEMI, and the rate of CAR was found to be significantly higher in patients with TIMI 0-1 flow in IRA ($p<0.001$).

Conclusion

CAR, an inflammatory marker in patients with STEMI, is known to influence the rates of mortality and morbidity. However, the relationship between CAR and IRA patency has not been investigated. This is the first study to reveal a significant relationship between the IRA patency and CAR before p-PCI in STEMI. The C-reactive protein/albumin ratio is an easy and reliable indicator that can be used to determine IRA patency in patients with STEMI.

Limitations of the study

The study has been carried out retrospectively. Methods such as cardiac nuclear imaging and cardiac MR, which are more specific and reliable, could be used to evaluate the reperfusion. However, their routine use is not possible in terms of cost and availability.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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