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Research article

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The relationship between fragmented QRS and mortality in without reversible defects patients with scintigraphical myocardial infarction diagnosis

Ahmet Salan [1], Ekrem Aksu [2], Sedat Köroğlu [3], Adem Doğaner [4]

[1] Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Nuclear Medicine, Kahramanmaras, Turkey
[2] Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Cardiology, Kahramanmaras, Turkey
[3] Kahramanmaras Necip Fazıl City Hospital Hospital, Department of Cardiology, Kahramanmaras, Turkey
[4] Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Statistics, Kahramanmaras, Turkey

ORCID ID of the author(s)

AS: 0000-0002-5022-1851
EA: 0000-0003-1939-1008
SK: 0000-0002-5138-0512
AD: 0000-0002-0270-9350

Corresponding Author
Ahmet Salan
Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Nuclear Medicine, Kahramanmaras, Turkey
E-mail: asalan@hotmail.com

Ethics Committee Approval
This study was approved by Kahramanmaraş Sütçü İmam University Clinical Research Ethics Committee in session 2019-18 with no. 2 on 16.10.2019.
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Evidence of increased mortality in perfusion abnormalities on myocardial perfusion scintigraphy (MPS) can be found. However, electrocardiography (ECG) is a cheaper and more easily accessible examination than MPS. Fragmented QRS (fQRS) is also considered to be associated with mortality in some cardiological diseases. The present study aimed to analyze the relationship between fQRS based on electrocardiography (ECG) and mortality in patients without reversible defects whose fixed hypoperfusion/perfusion defects were diagnosed and associated with myocardial infarction (MI) based on myocardial perfusion scintigraphy (MPS).

Methods: Non-ischemic patients (2289 patients) with MI diagnoses based on scintigraphy were selected based on retrospective scintigraphy reports. The presence of fQRS was investigated in 85 patients whose 12-lead electrocardiographs could be accessed from the hospital archive, and their deaths due to all causes were questioned from the death information system. The relationship between left ventricular ejection fraction (LVEF), fQRS, type of exercise, number of leukocytes, other parameters, and mortality rates was analyzed.

Results: The numbers of living (n = 69) and deceased (n = 16) patients were obtained. They were divided into two groups: (1) surviving patients (n = 69, number of fQRS positive 42) and (2) deceased (n = 16, number of fQRS positive 11). No distributional differences were found between mortality rates and fQRS and demographic features between groups (P = 0.558). However, a statistically significant effect was observed between mortality rates and low LVEF levels, pharmacological stress, number of leukocytes, and a low HDL level.

Conclusion: The present study suggests that it may be useful to define benign features of fQRS. LVEF levels may be a very important parameter in decision-making for pharmacological stress, and its role in prediction of mortality may be higher than that obtained by fQRS.

Keywords: Myocardial perfusion scintigraphy, Fragmented QRS, Myocardial infarction, Reversible defects, Mortality rate

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Introduction

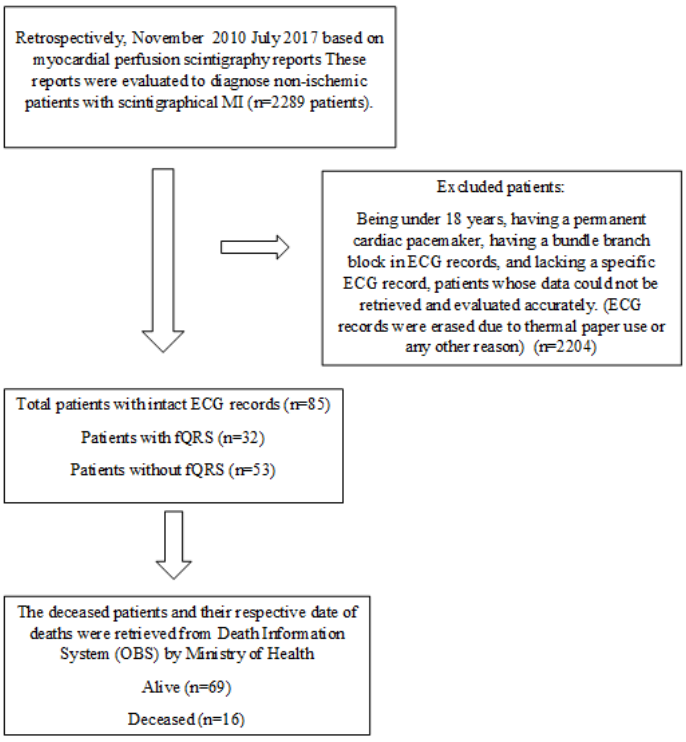
A significant correlation can be observed between non-sporadic fixed perfusion abnormalities and elevated all-cause mortality rate based on myocardial perfusion scintigraphy (MPS), which is used in the diagnosis and monitoring of coronary artery disease [1]. Ischemia and/or infarction interpretations can be made based on MPS reports by evaluating fixed perfusion abnormalities together with clinical data and functional findings. In MPS, fixed hypoperfusion is evaluated in favor of previous non-transmural MI and fixed perfusion defects are evaluated in favor of transmural MI under conditions that exclude chronic ischemia, whereas reversible defects are evaluated in favor of ischemia [2]. Myocardial fixed perfusion abnormalities are not peculiar to ischemic heart disease, and the distribution of mortality rates in patients with fixed perfusion abnormalities is heterogeneous. Therefore, diagnosis of patients with a higher mortality rate via monitoring their fixed hypoperfusion/perfusion defects based on MPS may contribute to the reduction of mortality rates. In this respect, new markers, which can be widely used in the diagnosis of patients with a higher mortality risk, are needed in present-day medicine. In recent years, in addition to fQRS, various hematological parameters have been used in the detection of patients with all-cause mortality risks [3]. fQRS can be defined as additional notching in the QRS complex and is caused by myocardial scarring/ischemia- or fibrosis-induced conduction abnormalities shown on the 12-lead ECG. The fQRS has attracted attention in the medical community as it offers advantages for predicting cardiac and all-cause mortality in patients with coronary artery disease [4–7]. It was reported that the presence of fQRS showed higher sensitivity in the diagnosis of MPS scars compared to pathological Q-wave in addition to being a specific marker for scar tissue [8]. In addition, it was demonstrated that some hematological markers correlated with both cardiovascular and elevated all-cause mortality rates [9]. The present study focused on the relationship between fQRS pattern and some hematological mortality markers and all-cause mortality rates in a group of acute non-ischemic patients with findings of MI based on MPS.

Materials and methods

The present study was conducted retrospectively at a nuclear medicine unit affiliated with a secondary healthcare institution between November 1, 2010, and July 31, 2017 based on MPS reports using a dual-headed E-Cam gamma camera (Siemens, Erlangen, Germany). These reports were evaluated to diagnose non-ischemic patients with scintigraphical-based MI (n = 2289 patients). The exclusion criteria for patients included several parameters: (1) less than18 years, (2) permanent cardiac pacemaker, (3) bundle branch block based on ECG records, and/or (4) lacking a specific ECG record. In addition, patients whose data could not be retrieved and evaluated accurately because ECG records were erased due to thermal paper use or any other reason were also excluded from the present study.

The patients who were hospitalized and yielded a sufficient amount of data in the hospital archive were selected for the present study. Among these 85 patients, those with and without fQRS pattern based on their respective ECG records were selected. A positive fQRS pattern was defined as notches in at least two consecutive leads in the same coronary artery area as observed on the QRS complex. ECG records were also evaluated by two experienced cardiologists for final analysis. The deceased patients and their respective dates of death were retrieved from Death Information System (OBS) by the Ministry of Health. The flow chart regarding the selection criteria of the patients included in the study is in figure 1. The effects of all causes on mortality, scintigraphic data, fQRS patterns, hematological parameters (numbers of leukocytes, neutrophils, and lymphocytes, erythrocyte distribution width [RDW-CW], thrombocyte distribution width [PDW], mean thrombocyte volume [MPV]), lipid profiles, and liver transaminase levels were analyzed. MPS reports were used to obtain data about the date of scintigraphy scan and various patient-related data, such as age, height, weight, stress protocol (pharmacological stress test or Bruce protocol), duration of stress, basal systolic and diastolic blood pressure levels prior to exercise, basal heart rate, exercise metabolic equivalent of task (METs) value, the presence of left ventricular wall motion abnormality, LVEF levels, dilation of left ventricular cavity, the presence of transmural and/or non-transmural myocardial infarction, and lesion localization (apex, anterior/septum, lateral, inferior, and multiple zone).

Figure 1: Flow chart shows the patient selection process



Declaration of ethics

The present study was designed in accordance with the principles of the Helsinki Declaration and approved by Kahramanmaras Sutcu Imam University Medical Faculty Clinical Research Ethics Committee in session 2019-18 with no. 2 on 10.16.2019.

Statistical analysis

The data normality distribution was analyzed using the Kolmogorov–Smirnov test for data analysis. For group comparisons, the independent sample t-test was used to compare normally distributed variables, while the Mann–Whitney U test was used for non-normally distributed data. Logistic regression

analysis was used to identify variables affecting mortality. Cox regression analysis was performed in order to reveal the relationship between lifespan and independent variables. Chi-squares and exact tests were used for distributional differences for categoric variables. Receiver operating characteristic (ROC) curves were used to determine mortality cut-off values for left ventricular ejection fraction (LVEF) levels. The level of statistical significance was taken as $P < 0.05$. Statistical parameters were given in Mean, standard deviation, and median (range 25%–75%). IBM SPSS Statistics version 22 (IBM SPSS for Windows version 22, IBM Corporation, Armonk, New York, United States) software package was used for data analysis.

Results

Eighty five patients included in the present study were divided into two groups as deceased (n = 16) and alive patients (n = 69). The living patients were monitored for median (Q1-Q3) at 59.00 (47.00–70.00) months, whereas the deceased patients were monitored for median (Q1-Q3) at 35.00 (13.00–50.00) months. Their demographic features, basal blood pressure/pulse rate levels, hematological levels, durations of exercise, and a comparison of MET values and LEVF levels between surviving and deceased patient groups are given in Table 1. No statistically significant differences were observed between the groups in terms of MI type, basal blood pressure and heart rate, and MET levels in terms of age, sex, body mass index (BMI), and number of leukocytes ($P > 0.05$). However, a statistically significant difference was observed between mortality and pharmacological exercise, a low LVEF level, the number of leukocytes, and a low high-density-lipoprotein (HDL) level.

ROC analysis, which aimed to calculate the predictive power of statistically significant LVEF marker between patient groups, demonstrated that cut-off values for AUC, sensitivity, specificity, and *P*-value were 0.720, 0.889, 0.562, and 0.006, respectively (Figure 2). In addition, the positive and negative predictive values (PPV and NPV, respectively) and accuracy for LVEF were calculated as 58.8%, 91.2%, and 84.7%, respectively.

The surviving and deceased patients were compared in terms of sex, stress protocol, left ventricular wall motion, transmural and/non-transmural MI, dilation of cavity, localization of perfusion abnormality based on MPS, and presence of fQRS. It was found that only the type of stress was significantly different among these two groups (Table 2).

Figure 2: The calculation of cut-off values for mortality rates in LVEF levels

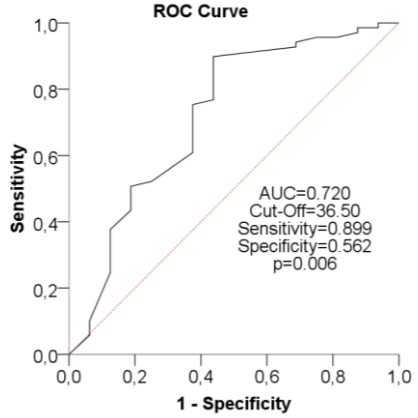


Table 1: Demographic, examination and laboratory data of the patients

		Deceased	Alive	*P*-value
Age (Years)	mean (SD)	65.19 (1.13)	62.94 (11.04)	0.474
Weight (Kilogram)	mean (SD)	81.5 (14.30	83.50 (14.38)	0.631
Height (Centimeter)	mean (SD)	161.69 (8.28)	163.4 (10.07)	0.468
Duration of stress (secs)	mean (SD)	443.00 (52.33)	465.00 (107.45)	0.661
Basal systolic blood pressure (mmHg)	median (Q1-Q3)	125.00(115.00-150.00)	130.00 (110.00–130.00)	0.598
Basal diastolic blood pressure (mmHg)	median (Q1-Q3)	80.00(70.00-90.00)	80.00 (70.00–80.00)	0.169
Basal heart rate (beats per minute)	mean (SD)	86.375 (22.665)	81.478 (15.182)	0.421
METs value	mean (SD)	9.150 (1.48)	9.142 (2.12)	0.995
LVEF (%)	median (Q1-Q3)	35.00 (28.50–50.50)	53.00 (45.00–59.00)	0.006*
Number of leukocytes (per microliter)	mean (SD)	9.78 (3.11)	7.95 (2.09)	0.038*
Hb (per deciliter)	median (Q1-Q3)	13.65 (12.15–14.70)	14.00 (12.40–15.10)	0.503
MPV (per microliter)	mean (SD)	9.60 (1.33)	10.03 (1.15)	0.245
LYM (%)	mean (SD)	2.37 (1.55)	2.23 (0.80)	0.737
RDW-CV (%)	mean (SD)	14.75 (1.99)	13.80 (1.68)	0.104
NEU (%)	mean (SD)	6.27 (3.10)	4.94 (2.13)	0.122
PDW (fL)	Median (Q1-Q3)	14.00(11.50-16.50)	12.60 (11.20–15.60)	0.381
AST (U/L)	mean (SD)	52.44 (83.99)	19.65 (6.10)	0.139
ALT (U/L)	mean (SD)	32.81 (59.76)	19.71 (9.88)	0.396
HDL (mg/dl)	mean (SD)	35.56 (9.84)	44.51 (11.98)	0.031*
LDL (mg/dl)	median (Q1-Q3)	100.50 (77.00–123.00)	96.00 (82.00–129.00)	0.992
NLR	median (Q1-Q3)	2.559 (1.624–4.666)	1.970 (1.653–2.909)	0.167
BMI	mean (SD)	31.111 (4.325)	31.36 (5.63)	0.846

Independent samples t test; Mann Whitney U test, α: 0.05, *Statistical significance, METs: metabolic equivalent of task, LVEF: Left ventricular ejection fraction, Hb: Hemoglobin, MPV: Mean thrombocyte volume, LYM: Number of lymphocytes, NEU: Number of neutrophils, RDW-CW: Erythrocyte distribution volume, PDW: Thrombocyte distribution width, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, HDL: High density lipoprotein, LDL: Low density lipoprotein, NLR: Neutrophil leukocyte ratio, BMI: Body mass index

Table 2: Comparison of surviving and deceased patient groups in terms of gender and scintigraphic characteristics

		Deceased		Alive		
		n	%	n	%	*P*-value
Sex	Female	5	20.0	20	80.0	0.858
	Male	11	18.3	49	81.7	
Type of stress	Pharmacological	14	26.9	38	73.1	0.019*
	Bruce	2	6.3	30	93.8	
Wall motion	Abnormal	12	21.1	45	78.9	0.497
	Normal	4	14.8	23	85.2	
MI type	Transmural	8	22.9	27	77.1	0.452
	Non-transmural	8	16.3	41	83.7	
	Unspecified	0	0.0	0	0.0	
Cavity width	Dilate	7	33.3	14	66.7	0.061
	Normal	9	14.1	55	85.9	
Lesion localization in MPS	Apex	3	25.0	9	75.0	0.298
	Anterior	1	9.1	10	90.9	
	Lateral	1	20.0	4	80.0	
	İnferior	3	10.0	27	90.0	
	Multiple zone	8	30.8	18	69.2	
fQRS	Yes	5	15.6	27	84.4	0.558
	No	11	20.8	42	79.2	

Chi-squared test; Exact test; α: 0.05; * distributional difference is statistically significant. MI: Myocardial Infarction, fQRS: fragmented QRS

In the logistic regression analysis, statistically significant effects were observed between the mortality and stress protocol, basal systolic blood pressure, LVEF level, number of leukocytes, and the neutrophil/leukocyte (NLR) ratio (Table 3).

The effects of the variables based on logistic regression analysis (leukocyte levels, basal systolic blood pressure, LVEF, stress protocol) and fQRS on survival were evaluated using a Cox regression analysis. While no statistically significant effect was found between fQRS and mortality rates, it was observed that other values were decisive variables for the lifespan of patients in the present study (Table 4).

Table 3: The effect of parameters on mortality with logistic regression analysis

	B	Wald	*P*-value	OR	95% CI	
					Lower	Upper
Stress protocol	-2.161	4.262	0.039*	0.115	0.015	0.896
Basal systolic blood pressure (mmHg)	-0.043	4.138	0.042*	0.958	0.919	0.998
LVEF (%)	0.124	7.552	0.006*	1.132	1.036	1.236
Number of leukocytes (per microliter)	-0.396	5.382	0.020*	0.673	0.481	0.940
NLR	-0.316	5.314	0.021*	0.729	0.558	0.954
Age (Years)		0.059	0.809			
Sex		0.339	0.560			
BMI		0.067	0.796			
Basal heart rate (beats per minute)		0.261	0.609			
Basal diastolic blood pressure (mmHg)		0.857	0.354			
Wall motion		4.021	0.134			
Cavity (Cavity width)		0.362	0.548			
MI type (MI type)		0.124	0.724			
Lesion localization in MPS		1.654	0.799			
Lesion localization in MPS						
Lesion localization in MPS (anterior)a		1.043	0.307			
Lesion localization in MPS (lateral)a		0.043	0.836			
Lesion localization in MPS (inferior)a		0.162	0.687			
Lesion localization in MPS (multiple zone)a		0.748	0.387			
fQRS		0.123	0.726			
Hb (per deciliter)		0.086	0.769			
MPV (per microliter)		0.094	0.759			
RDWCV (%)		0.928	0.335			
PDW (fL)		0.001	0.976			

Binary Logistic Regression: α: 0.05; Methods: LR; Nagelkerke's R^2: 0.498; Dependent Variable: Mortality; [a] Compared to reference group (Apex); * the effect is statistically significant, LVEF: Left ventricular ejection fraction, NLR: neutrophil leukocyte ratio, BMI: Body mass index, fQRS: fragmented QRS, Hb: Hemoglobin, MPV: Mean thrombocyte volume, RDW-CW: Erythrocyte distribution volume, PDW: Thrombocyte distribution width

Table 4: Parameters evaluated in cox regression analysis

	B	Wald	*P*-value	OR	OR 95% CI	
					Lower	Upper
fQRS	0.453	0.479	0.489	1.573	0.436	5.671
Number of leukocytes (per microliter)	0.312	5.722	0.017*	1.366	1.058	1.764
NLR	0.120	1.748	0.186	1.128	0.944	1.349
LVEF (%)	-0.052	4.280	0.039*	0.949	0.904	0.997
Basal systolic blood pressure (mmHg)	0.035	6.876	0.009*	1.035	1.009	1.062
Type of Stress	1.832	4.690	0.030*	6.249	1.190	32.816

OR; odds ratio, CI: confidence interval, Cox Regression: a: 0.05, * The effect is statistically significant; Dependent variables: Times, fQRS: fragmented QRS, NLR: neutrophil leukocyte ratio, LVEF: Left ventricular ejection fraction

Discussion

No statistically significant effect was observed between fQRS and all-cause mortality in the present study, which focused on non-ischemic patients with MI diagnoses based on scintigraphy. However, a negative correlation was found between LVEF levels and mortality. It has been reported in nuclear medicine practice that fixed lesions are likely to be correlated with poor prognosis based on non-sporadic MPS [6]. The presence of poor prognosis markers in patients with fixed perfusion defects has importance for reducing elevated cardiovascular mortality. fQRS is likely to become one of these markers as it is defined as additional notches on the QRS complex in at least two consecutive leads based on an ECG record and a display myocardial scar [4, 5]. Some studies have also reported that fQRS displays higher sensitivity in displaying scar tissue compared to the Q-wave [8]. In the existing literature, although the number of studies on the relationship between perfusion-induced mortality and fQRS is limited, many of these studies deal with its relationship with cardiovascular mortality [6, 10–13]. In a study monitoring MI and/or ischemia without any differentiation between transmural and non-transmural types on MPS in patients with coronary artery disease, fQRS was reported to be correlated with cardiac events (MI, need for revascularization, and cardiac death) [6]. Unlike the present study, another study which, due to cardiac events, excluded patients with scar tissue on MPS reports and included ischemic patients who underwent a coronary angiogram (CAG) reported that fQRS was a moderately sensitive and independent marker for ischemia diagnosis and showed a higher prognostic value compared to conventional risk factors [10]. Similarly, various studies showing that fQRS is likely to be an important marker for poor prognosis in ischemic patients have been published. For instance, a study on unstable patient groups without MPS in acute ischemic events indicated that fQRS was an independent predictor for all-cause mortality in patients with ACS [11]. Another study concerning acute ischemic patients who underwent a successful revascularization procedure found that unlike the conventional definition, fQRS was correlated with elevated in-hospital mortality even in a single lead in the same major cardiac area [12]. A similar study reported that the presence of fQRS during hospital admission can lead to an increase in mortality during cardiac events and long-term cardiovascular mortality in patients with non-ST elevated myocardial infarction. Based on these results in the existing literature, it is safe to assume a correlation between fQRS and poor prognosis in acute ischemic patients [13]. Therefore, the present study focused mainly on the predictive power of prognosis in patients with fixed hypoperfusion based on scintigraphical MI of fQRS.

In this study, fQRS morphology was found to have no prognostic value in patients with fixed perfusion anomalies. This result was not a surprising since the impact of fQRS on poor prognosis in ischemic patients has been reported in some previous studies. In addition, Das et al. reported that fQRS did not affect all-cause mortality, whereas it did affect cardiac events [6]. Because ischemic patients were excluded, the results of the present study also indicated that the presence of fixed defects did not play a prognostic role. Although they did not analyze its relationship with mortality, Ozdemir et al. [14] reported that the prevalence of ischemia and infarction in patients with fQRS in MPS was remarkably higher compared to the control group and that the probability of ischemia and/or infarction was both visually and quantitatively 10-fold higher compared to the patients without fQRS. In that study, fQRS in male patients was twice as high as in female patients. The presence of fQRS in normal MPS was associated with minimal fibrosis, inflammation, and/or early-stage CAD. Given that no effects were observed between fQRS and mortality in the present study and previously cited study, the results suggest the presence of probably benign fQRS with a higher level in male patients. It is widely known that fQRS patterns are not always malignant and do not occur at the same level for each lead. On the other hand, a study concerning patients with known and possible CAD reported that fQRS displayed a low sensitivity and specificity in terms of diagnosing myocardial scarring [15]. Although benign features of fQRS in anterior and lateral leads are relatively well-defined [16], the results of some studies suggest that some inferior leads are more likely to be benign. For instance, in a study on the prognostic importance of fQRS in inferior, anterior, and lateral leads, Terho et al. [17] reported that fQRS was prevalent in inferior leads, and the presence of fQRS without an

established heart disease did not indicate any cardiac event. fQRS in the lateral lead had the lowest incidence among these three leads; however, it had a higher risk of all-cause mortality. In a study comparing fQRS in inferior and anterior leads, Eyuboglu et al. [18] observed a correlation between fQRS in anterior leads and higher severity of multivessel disease. In particular, the presence of fQRS in lateral leads were found to be affected by cardiac events and all-cause mortality in patients with CAD [19]. Patients with fQRS in anterior leads had a 3.69-fold higher risk of abnormal MPS compared to those without fQRS in anterior leads, while the same levels were lower in inferior and lateral leads [20]. In the present study, it is likely that no effects would have been observed between fQRS and prognosis in patients with fixed hypoperfusion due to the dominant presence of fQRS morphology in the inferior leads. These results in the existing literature suggest that the relationship between fQRS and prognosis may differ depending on the selected patient groups and leads.

In this study, apart from fQRS, the demographic characteristics of the patients, MPS protocol, and the prognostic values of cardiovascular mortality markers obtained from laboratory tests were also investigated. These results also correlated with basal systolic blood pressure, leukocyte value, HDL levels, and NLR values. Another striking correlation was observed in patients who underwent pharmacological stress tests. The higher mortality rate in the patients who underwent pharmacological stress tests most likely resulted from their mobility limitations.

It was found that age, height, weight, body mass index (BMI), Bruce protocol stress test, duration of stress in Bruce protocol, (basal) diastolic blood pressure levels prior to exercise, basal heart rate, exercise METs values, left ventricular wall motion abnormality and dilation of cavity, type of MI (transmural/non-transmural), scintigraphic lesion localization, neutrophil, lymphocyte, RDW-CW, PDW, MPV, LDL cholesterol, ALT, and AST values were not correlated with mortality.

In the present study, it was observed that a higher NLR level and a lower LVEF level may have been correlated with elevated mortality in patients with fixed hypoperfusion/perfusion defects based on MPS. Similar to this finding, a study reported that the presence of fQRS was independently affected by a higher NLR in addition to elevated in-hospital mortality in patients with ST elevated myocardial infarction (STEMI). The presence of fQRS and the in-hospital mortality rate was higher in patients with NLR $\geq$ 5.47 in that study. In other words, it was suggested that NLR and fQRS were likely to offer additional prognostic clues in terms of diagnosing patients with a higher cardiac risk [21]. Similarly, despite no evidence of an association between fQRS and mortality, an association was observed between NLR and all-cause mortality in the present study. A similar study found an association between cardiac mortality and elevated NLR in patients with stabilized coronary artery disease. That study also analyzed the prognostic importance of LVEF level as a single variable predictor of mortality without focusing on the correlation between fQRS and mortality and observed a correlation between LVEF level and mortality in patients with LVEF $\leq$ 50, which overlaps with results related to LVEF in the present study [22]. In addition, the correlation between lower LVEF levels and all-cause mortality is a crucial result in the present study since decreased left ventricular systolic function may point to a higher-risk patient group [13]. Some studies concerning the prognostic role of LVEF levels can be found in the existing literature. For instance, similar to cut-off value in the present study (36.5%), a correlation was observed between low EF levels ($\leq$ 35%) and all-cause mortality rates in fragmented patients (including left bundle branch block, premature ventricular complex and paced QRS) with a QRS duration longer than 120 ms [7]. A study concerning patients with heart failure found a correlation between LVEF $\leq$ 45% and mortality [23]. Similarly, another study on patients with heart failure reported a higher cardiac death rate in patients with LVEF < 40% compared to those with a LVEF level higher than 40% [24]. In parallel with other studies in the existing literature, the present study found a negative correlation between LVEF levels and all-cause mortality rates in patients with fixed hypoperfusion/perfusion defects.

Limitations

The present study was designed based on a retrospective research model with limited duration of monitoring. The two most important limitations of the present study were the use of ECG records of hospitalized patients without any further automation records and the reliance on MPS reports without any MPS images in the automation system for the statistical analysis. Therefore, the number of patients included in the present study was fairly limited, which resulted in a relatively limited statistical analysis. Because the present study could not obtain MPS images and had to rely only on MPS reports for analysis, it was not possible to develop a model suitable to 17 different segments, resulting in a statistical analysis based on only five different segments.

Conclusions

Various studies in the existing literature have reported that fQRS is likely to be a marker associated with mortality and morbidity in cardiovascular diseases. However, no association was observed between fixed hypoperfusion in MPS and mortality and fQRS in the present study. It must be also noted that the patient group with fQRS morphology was a heterogeneous group in the present study. The results of the present study have importance in terms of indicating benign features of fQRS morphology in some patients, and it is evident that new markers are needed to diagnose such patients. In addition, future prospective studies must focus on the association between prognosis and fQRS and LVEF levels. A strong negative association was found between LVEF and mortality in the present study, which points to a correlation between LVEF levels and mortality. Another important result of the present study is the association between patients who underwent pharmacological stress tests and mortality. It can be suggested that in daily practice, LVEF level is likely to be a decisive factor for applying pharmacological stress tests. In conclusion, the present study demonstrated the need for larger volume prospective studies for the correlation between LVEF and prognosis in patients with fixed hypoperfusion/perfusion defects.

Nevertheless, the results of this study suggest that LVEF is a more useful predictor than fQRS for predicting all-

cause mortality in non-ischemic patients with fixed hypoperfusion/perfusion defects based on MPS.

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