ORIGINAL ARTICLE

Significance of fragmented QRS and predictors of outcome in ST-elevation myocardial infarction

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Background: Fragmented QRS (fQRS) might be associated with certain characteristics in ST-elevation myocardial infarction (STEMI) patients and inhospital adverse events. **Materials and Methods:** A sum of 500 patients were gone over retrospectively. Patients with STEMI, all undergone percutaneous coronary intervention, were grouped as fQRS (−) and fQRS (+). Characteristics of the patients, major adverse cardiac event (MACE), death in hospital, nonfatal myocardial infarction (MI), stent thrombosis, slow flow myocardial perfusion, development of ventricular tachycardia (VT) and fibrillation, cardiogenic shock and cardiopulmonary arrest were filtered. **Results:** FQRS (−) group was composed of 207 patients whose mean age was 61.1 ± 12.1, whereas 293 patients were there in fQRS (+) with a mean age of 66.7 ± 10.6 ($P < 0.001$). Thrombolysis in MI (TIMI) ($P < 0.01$), the global registry of acute coronary events (GRACE) ($P < 0.01$) scores, white blood cell count, neutrophil/lymphocyte ratio, MACE and the ratio of death in hospital and VT in the hospital were significantly higher in fQRS (+) group ($P < 0.001$, for remaining all). In multivariate logistic regression analysis, TIMI scores above 2 and GRACE scores above 109 were determined as independent predictors of MACE in the entire patient group (odds ratio [OR]: 2.022; 95% confidence interval [CI]; 1.321–3.424, $P = 0.003$; OR: 1.712; 95% CI: 1.156–2.804, $P = 0.008$). **Conclusion:** FQRS (+) and fQRS (−) patients markedly differ from each other in terms of certain demographic and clinical features and TIMI and GRACE scores have a significant predictive value for MACE in all STEMI patients' group.

Key words: Fragmented QRS, Global Registry of Acute Coronary eEvents score, neutrophil/lymphocyte ratio, ST-elevation myocardial infarction, thrombolysis in myocardial infarction score

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INTRODUCTION

Although deaths associated with cardiovascular disease (CVD) have been promisingly decreasing, it is still the most common cause of all deaths in middle-income countries of Europe.[1,2]

Coronary artery disease (CAD) can present with both an acute outcome and a chronic course. Recent studies showed that inflammatory processes are vigorously getting intricated into CAD pathology. Atherosclerosis should not be seen as a mere cholesterol-storage disease. Atherosclerosis is an active and perpetual disease fed by inflammatory processes. The breakdown of atherosclerotic plaque and causing acute coronary syndrome (ACS) is not related to the size or hardness of the plaque, but rather to the severity of the inflammatory process and its effect on the plaque.[3]

It has also been wondered whether fragmented QRS (fQRS) has any significant meaning for CAD, which has such a complex pathological process. fQRS is declared to be indicative of prognosis in ACS and ST-elevation myocardial infarction (STEMI).[4-6] fQRS on anterior leads is detected to result in a greater incidence

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of multivessel CAD.[7] In another study, while fQRS is found to be more frequent on inferior leads out of three, anterior, inferior, and lateral, fQRS on lateral is detected to present a more pronounced risk for all-cause mortality.[8] The clinical importance of fQRS is also endeavored to get revealed using a series of studies that evaluate CVD and cardiomyopathies or certain diseases originating from other systems apart from the cardiovascular system, such as obstructive sleep apnea, cirrhosis, and renal diseases.[9,10]

Aim

Our aim in our study is to determine whether there is a significant difference in the demographic and clinical characteristics of STEMI patients who have undergone percutaneous coronary intervention (PCI) and the frequency of inhospital adverse events in relation to the presence or absence of fQRS, and to ascertain the possible association of thrombolysis in myocardial infarction (TIMI) and Global Registry of Acute Coronary Events (GRACE) scores and certain parameters with increased likelihood of developing major adverse cardiac events in the entire patient group.

MATERIALS AND METHODS

This study was designed retrospectively and single centered in the Cardiology Department of Adıyaman University Training and Research Hospital. Data from 500 patients obtained who applied to the emergency service or cardiology outpatient clinic and were diagnosed with STEMI, undergone medical care in the coronary intensive care unit following PCI, between January 01, 2017 and December 31, 2019. The study was initiated with the approval of the local ethical committee dated May 21, 2019 and numbered 2019/4-2. The study was carried out in accordance with the Declaration of Helsinki.

We calculated a total sample size of 210 with an alpha error of 5% and a power of 95. TIMI and the GRACE scores were assessed to determine the short- and middle-term risks related to those patients. Transthoracic echocardiography results were obtained from the automation network. Patients with pregnancy, malignancy, chronic inflammatory diseases, connective tissue disorders, systemic infection findings in the last 48 h before diagnosis, active liver disease or cirrhosis and multi-organ dysfunction were excluded from the study. Archive and electrocardiogram (ECG) recordings belongs to the first admission were analyzed.

According to fourth universal definition of myocardial infarction (MI), a new ST elevation at the J point of two contiguous leads other than V2 and V3, at least as being ≥1 mV, (>0.2 mV in over 40-year-old men, >0.25 mV in below 40-year-old men and >1.5 mV in women all age groups, for V2 and V3 leads) and troponin I values above 0.025 ng/mL are accepted as diagnostic criteria of STEMI.[11]

fQRS is defined as the existence of an RSR′ pattern (QRS <120 ms) or an additional R (R′) or a notched S wave in a coronary artery territory of ECG, provided that these should be in the absence of complete or partial bundle branch block.[7,8] As for RSR′ pattern, it means an extra R wave or a notched S wave. Lastly, to diagnose a fQRS, the presence of those morphological changes at least in two contagious derivations of ECG recording are required. Accordingly, morphological changes in two contagious anterior (V1–V5) leads correspond to the anterior or left anterior descending territory, those in two contagious lateral (D1, aVL, V6) leads correspond to the lateral or left circumflex territory, and those in two contagious inferior (D1, D2, aVF) leads correspond to the inferior or right coronary arter territory.

Customary techniques were followed for all PCI processes. Serum electrolytes, plasma glucose, blood urea nitrogen, creatinine, aspartate aminotransferase, alanine transaminase, and complete blood count measurements taken at the time of admission were acquired from the automation system. To go into detail, hemoglobin (Hgb), hematocrit, lymphocyte ratio, white blood cell (WBC), neutrophil, absolute neutrophil, absolute lymphocyte, and thrombocyte counts were listed. Major adverse cardiac events (MACE), inhospital death, nonfatal MI (NFMI), stent thrombosis, inhospital arrhythmias such as ventricular tachycardia (VT) and ventricular fibrillation (VF), cardiogenic shock, and cardiopulmonary arrest cases were revealed by debriefing patient folders. MACE was defined as a sum of overall cardiovascular deaths because of MI, stroke, hospitalization due to heart failure, and revascularization yet including PCI or coronary artery bypass graft.

The data were analyzed using the IBM SPSS Statistics® version 24 (IBM Corp, Armonk, NY, USA) statistical program. Whether the data were normally distributed or not was sorted out with the Kolmogorov–Smirnov test. Continuous variables, may be normally or nonnormally distributed, were portrayed as mean ± standard deviation and, whereas categorical variables were in percentile (%). Student's *t*-test was used for comparison of normally distributed variables and Mann–Whitney *U*-test was used when they were seen to be nonnormally distributed. How many independent variables predict MACE in the entire patient group were revealed by using multivariate logistic regression analysis. The data in $P < 0.20$ range in univariate regression analysis were included in multivariate logistic regression analysis. Independent predictors were determined. $P < 0.05$ was accepted as statistically significant.

RESULTS

Patients separated into two groups, as being fQRS (−) ones in group 1 and fQRS (+) ones in group 2. There were 207 patients in group 1, whereas 293 patients were in group 2. While the mean age of group 1 was 61.1 ± 12.1, the mean age of group 2 was 66.7 ± 10.6, and there was a significant difference ($P < 0.001$). The male ratio was significantly higher in group 2 ($n = 161$, $n = 183$, $P < 0.001$). Among the risk factors, diabetes mellitus (DM), smoking, hypertension (HT), and hyperlipidemia (HL) were more common in group 2 ($P < 0.001$). Pulmonary arterial HT was more prevalent in group 2, too ($P < 0.01$). Previous PCI history for both the patient himself and family was also significantly more frequent in group 2 ($P < 0.001$). Both TIMI and GRACE scores were higher in group 2 ($P < 0.01$). Chronic obstructive pulmonary disease was comparably common in both groups ($P > 0.05$). The groups were also comparable with regard to previous stroke history ($P > 0.05$). In addition, body mass index, left ventricular ejection fraction (LVEF), plasma glucose, creatinine, creatinine clearance, total cholesterol (TC), triglyceride (TG), high-density lipoprotein, low-density lipoprotein, Hgb and platelet count did not markedly differ between groups ($P > 0.05$). WBC and neutrophil/lymphocyte ratio (NLR) were found to be significantly higher in group 2 ($P < 0.001$). In fQRS (+) group, lymphocyte count is significantly lower and neutrophil is higher ($P = 0.012$ and $P = 0.008$, respectively) [Table 1].

MACE, inhospital death and VT ratios were also markedly higher in group 2 ($P < 0.001$). NFMI, cardiogenic shock, and cardiopulmonary arrest were also significantly higher in group 2 ($P = 0.009$, $P = 0.012$, $P = 0.033$, respectively). Stent thrombosis, slow flow myocardial perfusion, no reflow, and inhospital VF did not differ between groups ($P > 0.05$) [Table 2]. In multivariate logistic analysis, TIMI scores above 2 and GRACE scores above 109 were determined as independent predictors of MACE in the entire STEMI patients (Odds ratio [OR]: 2.022; 95% confidence interval [CI]; 1.321–3.424, $P = 0.003$; OR: 1.712; 95% CI: 1.156–2.804, $P = 0.008$) [Table 3].

Table 1: Demographic and clinical characteristics of patients with ST segment elevation

Characteristics	Group 1 (*n*=207) fQRS (–)	Group 2 (*n*=293) fQRS (+)	*P*
Mean age, mean±SD	61.1±12.1	66.7±10.6	<0.001
Gender, male, *n* (%)	161 (77.8)	183 (62.5)	<0.001
DM, *n* (%)	12 (5)	25 (8)	<0.001
Smoking, *n* (%)	70 (33.0)	113 (38.5)	<0.001
HT, *n* (%)	63 (30)	75 (25.5)	<0.001
HL, *n* (%)	13 (6)	37 (12)	<0.001
COPD, *n* (%)	16 (7)	19 (6)	0.354
PAH, *n* (%)	22 (10)	31 (10)	0.008
Previous PCI, *n* (%)	72 (34.7)	83 (28.3)	<0.001
Stroke history, *n* (%)	16 (7)	20 (6)	0.089
Family history of PCI, *n* (%)	40 (19.3)	66 (22.5)	<0.001
BMI (kg/m²)	25.6±3.8	26.0±4.0	0.234
TIMI score	2.9±1.4	3.7±1.0	0.002
GRACE score	103.6±22.1	122.6±24.3	0.008
LVEF (%)*	58.4±3.4	57.9±3.2	0.053
Glucose (mg/dL)	118.4±58.6	119.0±57.9	0.817
Creatinine (mg/dL)	0.84±0.1	0.81±0.2	0.173
Creatinine clearance (mL/min)	99.1±56.6	107.2±47.9	0.170
Total cholesterol (mg/dL)	175.1±39.3	179.4±40.9	0.134
Triglyceride (mg/dL)	138.6±33.7	142.9±25.8	0.351
HDL (mg/dL)	32.8±8.6	31.4±8.3	0.678
LDL (mg/dL)	118.7±10.1	120.6±18.5	0.498
WBC (10≥×μL)	9.3±1.6	14.9±1.8	<0.001
Neutrophil (10≥×μL)	7.6±2.8	11.9±3.4	0.008
Lymphocyte (10≥×μL)	2.0±0.5	1.2±0.3	0.012
Neutrophil/lymphocyte ratio	6.4±0.6	7.5±1.5	<0.001
Hgb (g/dL)	14.5±0.9	13.5±1.8	0.342
Platelet (10≥×μL)	229.8±61.0	231.9±65.4	0.895

*LVEF values of groups were compared after 1-year percutaneous coronary intervention and patients who developed MACE, nonfatal MI, in–hospital VF and VT, cardiogenic shock, and cardiopulmonary arrest or died in the 1 year follow-up time were excluded from this comparison (*n*=165 in group 1 and *n*=139 in group 2). BMI=Body mass index; DM=Diabetes mellitus; GRACE=Global registry of acute coronary events; HT=Hypertension; HDL=High-density lipoprotein; HL=Hyperlipidemia; LDL=Low -density lipoprotein; LVEF=Left ventricular ejection fraction; COPD=Chronic obstructive pulmonary disease; PAH= Pulmonary arterial hypertension; PCI=Percutaneous coronary intervention; TIMI=Thrombolysis in myocardial infarction; SD=Standard deviation; Hgb=Hemoglobin; fQRS=Fragmented QRS; PAH=Pulmonary arterial hypertension; WBC=White blood cell; VT=Ventricular tachycardia; VF=Ventricular fibrillation; MI=Myocardial infarction; MACE=Major adverse cardiac events

DISCUSSION

The results of the study, which compares STEMI patient groups defined as fQRS (−) and fQRS (+) according to the ECG recordings, indicated that (1) Demographic and clinical characteristics of fQRS (+) patients is differed from fQRS (−) ones [Table 1]; (2) Co–morbidities and risk factors were found to be more prevalent in fQRS (+) group; (3) Previous PCI history was more common, TIMI and GRACE scores were higher, MACE, inhospital death and VT were more frequent in fQRS (+) group; (4) Neutrophil, NLR, and WBC were higher and lymphocyte was lower in fQRS (+) group; and (5) TIMI (>2) and GRACE (>109) scores were discovered to be independent determinants of MACE in all STEMI patients group.

Mass of studies are in literature declaring a possible relation between fQRS and CVD. Morrow *et al*. revealed that the existence of fQRS is an autonomous predictor of mortality depended upon CVD and hospitalization due to heart failure in post-MI period, in which study 158 MI patients are followed up for 50 months.[12] Another study, conducted by Das *et al*., proposes that the existence of fQRS implies regional deteriorations in myocardial perfusion, and even

maps the fibrotic areas, better than Q wave abnormalities.[13] In fact, it is suggested that fQRS (+) finding is an indicator of poor prognosis in patients with HT and a finding of left ventricular HT and uncontrolled HT in particular.[14,15] In addition, cardiac performance decreases depending on the size of the infarct area. According to certain studies, the presence of fQRS is found to be encountered more frequently in hospitalized ACS patients, and the long–term mortality due to cardiac events is higher in these patients.[4,16,17] Even after an appropriate revascularization intervention, fQRS (+) is associated with poor outcomes in patients with AMI.[18] It is also possible to come across studies in the literature showing that the presence of fQRS is an important predictor of the course in STEMI patients. According to one of those studies, all-cause mortality is found to be significantly higher in fQRS (+) STEMI patients who underwent PCI compared to the fQRS (−) group.[19] As for another study, inhospital mortality and contrast nephropathy are both more frequent after PCI in fQRS (+) STEMI patients.[20] In addition, according to a meta-analysis study that included six studies, the mortality rate is found to be three times higher in STEMI patients in case fQRS exists.[21] In our study, the significant differences between the demographic and clinical characteristics of fQRS (+) and (−) STEMI patients who underwent PCI are seemed to be consistent with and enlarging the literature information.

Table 2: Inhospital adverse events and procedural success in patients with ST-segment elevation

	Group 1 (*n*=207) fQRS (–), *n* (%)	Group 2 (*n*=293) fQRS (+), *n* (%)	*P*
MACE	14 (6)	60 (20)	<0.001
In-hospital mortality	1 (0)	8 (2)	<0.001
Non-fatal MI	2 (3)	5 (12)	0.009
Stent thrombosis	30 (14)	50 (17)	0.324
Slow flow	18 (8)	40 (13)	0.072
No-reflow	12 (5)	20 (6)	0.256
In-hospital VT	2 (0)	12 (4)	<0.001
In-hospital VF	14 (6)	29 (9)	0.116
Cardiogenic shock	4 (1)	19 (6)	0.012
Cardiopulmonary arrest	5 (2)	21 (7)	0.033

VT=Ventricular tachycardia; VF=Ventricular fibrillation; MACE=Major adverse cardiac events; fQRS=Fragmented QRS; MI=Myocardial infarction

Because inflammation is a plausible target to prevent and follow–up the outcomes of atherosclerosis, NLR has been dwelled on in predicting cardiovascular events. In a recent study, NLR is found to be vigorously associated with the risk of all CVDs, MI, and ischemic stroke.[22] Higher NLR and lower lymphocyte monocyte ratio are found to be associated with MACE.[23] In some other studies, a higher NLR is revealed to be an eloquent biomarker for the prediction of vulnerability in carotid plaques, stent stenosis, and long–term MACEs.[24,25] Recently, in a study, the association of NLR and fQRS (+) is so well emphasized. Accordingly, NLR is declared to be associated with the existence of fQRS (+), STEMI patients having an NLR above the cut–off value of 5.47 manifest a higher frequency fQRS (+) and inhospital mortality.[26] In our study, we found out a higher NLR, higher scores of TIMI and GRACE scores, higher incidence of MACE, nonfatal MI, inhospital mortality, inhospital VT, cardiogenic shock, cardiopulmonary arrest in fQRS (+) group. Besides, we revealed that the risk of developing MACE increases in STEMI patients with TIMI scores >2, and with GRACE scores >109. One of meta-analysis indicates that the TIMI score is more valuable in predicting MACEs in acute chest pain patients compared to the GRACE score, as is the case in our study the TIMI score above the cut-off increases the MACE risk most sharply.[27] In a study, TIMI scores are found to be positively correlated with inflammatory biomarkers such as interleukin (IL-6), IL-1ß, and malondialdehyde in unstable angina patients, and IL-1ß in STEMI patients.[28] In another study which reveals the significance of NLR and fQRS existence in predicting cardiac events, NLR is detected to be higher in hypertrophic cardiomyopathy (HCM) patients.[29] Besides, it is declared to be associated with ventricular arrhythmia and the existence of fQRS (+) in HCM patients. It has been shown that fQRS (+) is observed more frequently and neutrophil is detected to be significantly higher even in individuals who are otherwise healthy but have a first-degree relative with any CVD.[30]

Table 3: Independent determinants of major adverse cardiac events in patients with ST-elevation myocardial infarction, logistic regression analysis results

	Univariate analysis			Multivariate analysis		
	Coefficients	95% CI	*P*	OR	95% CI	*P*
TIMI score (>2)	2.885	1.504–3.362	<0.001	2.022	1.321–3.424	0.003
GRACE score (>109)	1.820	1.006–2.333	0.004	1.712	1.156–2.804	0.008
LVEF	1.112	0.300–1.671	0.745			
NLR (>3.5)	1.478	0.970–1.831	0.145			
DM	0.762	0.307–1.888	0.557			
HT	1.312	0.807–1.921	0.245			
COPD	1.238	0.419–3.260	0.700			

Variables with *P*<0.20 in univariate regression were included into the multivariate logistic regression analysis. COPD=Chronic obstructive pulmonary disease; DM=Diabetes mellitus; GRACE=Global registry of acute coronary events; HT=Hypertension; LVEF=Left ventricular ejection fraction; NLR=Neutrophil/lymphocyte ratio; TIMI=Thrombolysis in myocardial infarction; CI=Confidence interval; OR=Odds ratio

According to one of the previous studies, the existence of fQRS does not result in a significant difference in baseline (post-PCI) LVEF of STEMI patients in comparison to those who do not exhibit fQRS.[31] However, in that study, a significantly lower LVEF is observed in fQRS (+) STEMI patients, at the end of 1-month follow–up. STEMI patients in that study have a much younger mean age than those in our study. In our study, we compared LVEF values recorded in 1 year follow-up examination of STEMI patients with fQRS or not. Furthermore, we excluded the patients who developed MACE, nonfatal MI, inhospital VF and VT, cardiogenic shock, and cardiopulmonary arrest or died in the 1 year follow-up time from groups. fQRS is already known as a significant predictor of MACE and long–term mortality.[18,19] In another study that examines STEMI patients involving a comparable age group to those in our study, the post-PCI LVEF is found to be 55.95 ± 9.47 in fQRS (−) and 51.3 ± 11.92 in fQRS (+) groups, respectively, which indicates a marked difference.[32] If we speculate, whether fQRS persists or not seems to be more important than whether the patient has fQRS at admission or in the vicinity of post-PCI course. Indeed, Umapathy *et al*. already reported that a significant difference between the LVEF values of fQRS (+) and (−) groups emerges when patients are compared by excluding patients in whom fQRS do not persist, 1 month later.[31]

Main limitations of the study: (1) The study was a single-center and cross-sectional, (2) the demographic and clinical differences between fQRS (+) and (−) STEMI patients were not detailed by considering subsequent procedures after first admission, such as coronary angiography or myocardial perfusion scintigraphy, (3) The changes in fQRS existence during follow-up, how long it persisted, and the classification and number of fQRS (+) leads at the first admission did not be analyzed, (4) The fQRS (+) and (−) groups were not adjusted according to the age and gender differences because of aiming to reveal all differences regarding the characteristics of the patients, which also could be regarded a remarkable limitation.

CONCLUSION

A markedly higher neutrophil and lymphocyte counts, NLR, TIMI and GRACE scores, MACE, inhospital mortality, nonfatal MI, cardiogenic shock, cardiopulmonary arrest, and in–hospital VT are encountered in fQRS (+) group. TIMI and GRACE scores are powerful independent determinants of MACE in STEMI patients. This data suggest that fQRS (+) and fQRS (−) patients markedly differ from each other in terms of certain demographic and clinical features and TIMI and GRACE scores have a significant predictive value for MACE in STEMI patients.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Timmis A, Vardas P, Townsend N, Torbica A, Katus H, De Smedt D, *et al.* European Society of Cardiology: Cardiovascular disease statistics 2021: Executive summary. Eur Heart J Qual Care Clin Outcomes 2022;8:377-82.
2. SIGN. Risk Estimation and the Prevention of Cardiovascular Disease. Edinburgh: SIGN. (SIGN Publication No. 149); 2017. Available from: https://collections.nlm.nih.gov/catalog/nlm:nlmuid-101714866-pdf. [Last accessed on 2023 Jul 11].
3. Libby P. The biology of atherosclerosis comes full circle: Lessons for conquering cardiovascular disease. Nat Rev Cardiol 2021;18:683-4.
4. Tanriverdi Z, Colluoglu T, Unal B, Dursun H, Kaya D. The prognostic value of the combined use of QRS distortion and fragmented QRS in patients with acute STEMI undergoing primary percutaneous coronary intervention. J Electrocardiol 2018;51:210-7.
5. Korhonen P, Husa T, Konttila T, Tierala I, Mäkijärvi M, Väänänen H, *et al.* Fragmented QRS in prediction of cardiac deaths and heart failure hospitalizations after myocardial infarction. Ann Noninvasive Electrocardiol 2010;15:130-7.
6. Paszek E, Zajdel W, Plens K, Żmudka K, Legutko J, Kleczyński P. Low profilin 1 serum levels are associated with diabetes, family history and multivessel lesions in patients with coronary artery disease. Postepy Kardiol Interwencyjnej 2021;17:305-8.
7. Eyuboglu M, Kucuk U, Senarslan O, Akdeniz B. Comparison of the presence of fragmented QRS complexes in the inferior versus the anterior leads for predicting coronary artery disease severity. Rev Port Cardiol 2017;36:89-93.
8. Terho HK, Tikkanen JT, Junttila JM, Anttonen O, Kenttä TV, Aro AL, *et al.* Prevalence and prognostic significance of fragmented QRS complex in middle-aged subjects with and without clinical or electrocardiographic evidence of cardiac disease. Am J Cardiol 2014;114:141-7.
9. Take Y, Morita H. Fragmented QRS: What is the meaning? Indian Pacing Electrophysiol J 2012;12:213-25.
10. Supreeth RN, Francis J. Fragmented QRS – Its significance. Indian Pacing Electrophysiol J 2020;20:27-32.
11. Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, *et al.* Fourth universal definition of myocardial infarction (2018). Circulation 2018;138:e618-51.
12. Morrow DA, Antman EM, Parsons L, de Lemos JA, Cannon CP, Giugliano RP, *et al.* Application of the TIMI risk score for ST-elevation MI in the national registry of myocardial infarction 3. JAMA 2001;286:1356-9.
13. Das MK, Khan B, Jacob S, Kumar A, Mahenthiran J. Significance of a fragmented QRS complex versus a Q wave in patients with coronary artery disease. Circulation 2006;113:2495-501.
14. Altunova M, Püşüroğlu H, Karakayalı M, Şahin AA, Demir AR, Yılmaz E, *et al.* Relationship between fragmented QRS complex and long-term cardiovascular outcome in patients with essential hypertension. Anatol J Cardiol 2022;26:442-9.
15. Eyuboglu M. Fragmented QRS as a marker of myocardial fibrosis in hypertension: A systematic review. Curr Hypertens Rep 2019;21:73.
16. Das MK, Suradi H, Maskoun W, Michael MA, Shen C, Peng J, *et al.* Fragmented wide QRS on a 12-lead ECG: A sign of myocardial scar and poor prognosis. Circ Arrhythm Electrophysiol 2008;1:258-68.

17. Kadı H, Ceyhan K, Koç F, Celik A, Onalan O. Relation between fragmented QRS and collateral circulation in patients with chronic total occlusion without prior myocardial infarction. Anadolu Kardiyol Derg 2011;11:300-4.
18. Zhang R, Chen S, Zhao Q, Sun M, Yu B, Hou J. Fragmented QRS complex is a prognostic marker of microvascular reperfusion and changes in LV function occur in patients with ST elevation myocardial infarction who underwent primary percutaneous coronary intervention. Exp Ther Med 2017;13:3231-8.
19. Akgul O, Uyarel H, Pusuroglu H, Surgit O, Turen S, Erturk M, *et al.* Predictive value of a fragmented QRS complex in patients undergoing primary angioplasty for ST elevation myocardial infarction. Ann Noninvasive Electrocardiol 2015;20:263-72.
20. Kurtul A, Duran M. Fragmented QRS complex predicts contrast-induced nephropathy and in-hospital mortality after primary percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction. Clin Cardiol 2017;40:235-42.
21. Kanjanahattakij N, Rattanawong P, Riangwiwat T, Prasitlumkum N, Limpruttidham N, Chongsathidkiet P, *et al.* Fragmented QRS and mortality in patients undergoing percutaneous intervention for ST-elevation myocardial infarction: Systematic review and meta-analysis. Ann Noninvasive Electrocardiol 2018;23:e12567.
22. Zhao Y, Zhang S, Yi Y, Qu T, Gao S, Lin Y, *et al.* Neutrophil-to-lymphocyte ratio as a predictor for cardiovascular diseases: A cohort study in Tianjin, China. J Hum Hypertens 2023;37:576-83.
23. Kristono GA, Holley AS, Harding SA, Larsen PD. White blood cell subtypes as predictors of adverse cardiac events. Coron Artery Dis 2020;31:446-50.
24. Agarwal R, Aurora RG, Siswanto BB, Muliawan HS. The prognostic value of neutrophil-to-lymphocyte ratio across all stages of coronary artery disease. Coron Artery Dis 2022;33:137-43.
25. Li X, Li J, Wu G. Relationship of neutrophil-to-lymphocyte ratio with carotid plaque vulnerability and occurrence of vulnerable carotid plaque in patients with acute ischemic stroke. Biomed Res Int 2021;2021:1-8.
26. Tanriverdi Z, Colluoglu T, Dursun H, Kaya D. The relationship between neutrophil-to-lymphocyte ratio and fragmented QRS in acute STEMI patients treated with primary PCI. J Electrocardiol 2017;50:876-83.
27. Ke J, Chen Y, Wang X, Wu Z, Chen F. Indirect comparison of TIMI, HEART and GRACE for predicting major cardiovascular events in patients admitted to the emergency department with acute chest pain: A systematic review and meta-analysis. BMJ Open 2021;11:e048356.
28. Paula da Silva MV, Villar-Delfino PH, Nogueira-Machado JA, Oliveira Volpe CM. IL-6, IL-1β and MDA correlate with thrombolysis in myocardial infarction (TIMI) risk score in patients with acute coronary syndrome. Recent Adv Inflamm Allergy Drug Discov 2022;15:71-79. [doi: 10.2174/2772270816666220211091231].
29. Ozyilmaz S, Akgul O, Uyarel H, Pusuroglu H, Gul M, Satilmisoglu MH, *et al.* The importance of the neutrophil-to-lymphocyte ratio in patients with hypertrophic cardiomyopathy. Rev Port Cardiol 2017;36:239-46.
30. Abuş S, Afşin A. Fragmented QRS in the relatives of patients with coronary artery disease. Ann Noninvasive Electrocardiol 2022;27:e12970.
31. Umapathy S, Yadav R, Goswami KC, Karthikeyan G, Parakh N, Bahl VK. Prognostic significance of fragmented QRS in patients with ST-elevation myocardial infarction undergoing revascularization. Indian Heart J 2018;70 Suppl 3:S126-32.
32. Ma X, Duan W, Poudel P, Ma J, Sharma D, Xu Y. Fragmented QRS complexes have predictive value of imperfect ST-segment resolution in patients with STEMI after primary percutaneous coronary intervention. Am J Emerg Med 2016;34:398-402.