Relation between fragmented QRS and collateral circulation in patients with chronic total occlusion without prior myocardial infarction

Miyokart enfarktüsü geçirmemiş kronik total oklüzyonlu hastalarda fragmente QRS ve koroner kollateral akım arasındaki ilişki

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ABSTRACT

Objective: It has been shown that the fragmented QRS (fQRS) on electrocardiogram (ECG) signifies regional myocardial scar in patients with non-Q-wave myocardial infarction (MI). We hypothesized that presence of fQRS on ECG may be related with poorly-grown collateral coronary circulation (CCC) in patients with chronic total coronary occlusion (CTO) without prior MI.

Methods: This retrospective observational study is included 56 patients (mean age 61.73±7.96 years; 67.9% men) with CTO in one of the major coronary arteries. Collateral circulation was graded according to Rentrop's classification. The fQRS was defined as the presence of an additional R wave or notching of R or S wave or the presence of fragmentation in two contiguous ECG leads corresponding to a major coronary artery territory. Patients with pathological Q-wave or history of MI, typical bundle brunch blocks (BBB) and incomplete right BBB were excluded from study. Statistical analysis was performed using Chi-square test, Student's t-test and logistic regression analysis.

Results: Fifteen patients had Rentrop grade 1, 15 patients had grade 2 and 26 patients had grade 3 CCC. Five (19%) of the patients who have grade 3 CCC, seven (47%) of the patients who had grade 2 CCC, ten (67%) of the patients who had grade 1 CCC had fQRS (p=0.002). Logistic regression analysis showed high predictive value of the presence of fQRS for Rentrop 1 CCC (OR=8.4, 95% CI 1.97-35.7; p=0.004).

Conclusion: Results of our study may implicate the presence of fQRS on electrocardiogram as a predictor of a poorly grown CCC in patients with chronic total occlusion without prior MI. *(Anadolu Kardiyol Derg 2011; 11: 300-4)*

Key words: Fragmented QRS, coronary collateral circulation, chronic total occlusion, logistic regression analysis

ÖZET

Amaç: Yapılan çalışmalarda, elektrokardiyogramdaki (EKG) fragmente QRS'in (fQRS) Q dalgasız miyokart enfarktüslü (Mİ) hastalarda bölgesel miyokardiyal skarı gösterdiği bildirilmiştir. Koroner arter hastalığı olan hastalarda, koroner kollateral dolaşımın enfarktüs veya iskemiyi önleyebileceği birçok çalışmada gösterilmiştir. Biz bu çalışmada; EKG'deki fQRS varlığının, daha önce Mİ geçirmemiş kronik total oklüzyonlu hastalarda kollateral gelişim ile ilişkisini göstermeyi amaçladık.

Yöntemler: Geriye dönük gözlemsel çalışmamızda, çalışma grubumuz; bir majör koroner arteri tam tıkalı olan 56 hastadan oluşmaktadır (ortalama yaş 61.73±7.96 yıl; %67 erkek). Kollateral dolaşım derecelendirilmesi Rentrop sınıflamasına göre yapıldı. Fragmente QRS; majör koroner arter bölgesine uyan, birbirine bitişik en az iki derivasyonda ikinci bir R dalgasının (R') varlığı, R ya da S dalgasının çentikleşmesi ya da R dalgasının fragmentasyonu (birden fazla R') olarak tarif edildi. Miyokart enfarktüsü hikayesi, EKG'de patolojik Q dalgası veya tipik dal bloğu ya da inkomplet sağ dal bloğu olan hastalar çalışmadan dışlandı. İstatistiksel analiz Ki-kare testi, Student t-testi ve lojistik regresyon analiz ile yapıldı.

Bulgular: Çalışma grubundaki 56 hastanın 22'si (%39) EKG'de fQRS'e sahipti. Hastaların 15'i (%27) Rentrop 1, 15'i (%27) Rentrop 2 ve 26'sı (%46) Rentrop 3 kollateral dolaşıma sahipti. Rentrop 3 kollateral dolaşıma sahip hastaların 5'i (%19), Rentrop 2 kollateral dolaşıma sahip olanların 7'si (%47), Rentrop 1 kollateral akıma sahip olanların 10'u (%67) EKG'de fQRS'e sahipti (p=0.002). Lojistik regresyon analizlerinde Rentrop 1 kollateral dolaşım için fQRS'in prediktif değeri yüksek bulundu (OR=8.4, %95 GA 1.97-35.7, p=0.004).

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Sonuç: Çalışmamızın sonuçları Mİ'ne sahip olmayan kronik total oklüzyonlu hastalarda, EKG'de fQRS varlığının iyi gelişmemiş kollateral dolaşımın bir prediktörü olabileceğini düşündürmektedir. *(Anadolu Kardiyol Derg 2011; 11: 300-4)*
Anahtar kelimeler: Fragmente QRS, koroner kollateral dolaşım, kronik total oklüzyon, lojistik regresyon analizi

Introduction

The evidence of prior transmural myocardial infarction (MI) is the pathological Q-waves on standard 12-lead ECG (1). There is no established electrocardiographic (ECG) sign for a prior MI in the absence of pathological Q-wave on ECG. Recently, it has been shown that the fragmented QRS (fQRS) on ECG signifies regional myocardial scar in patients with non-Q-wave MI (2). Consistent with this, the presence of fQRS on 12- lead ECG was shown to be associated with all cause mortality and recurrent cardiac events (3). In addition, the fQRS was associated with arrhythmic events in patients with nonischemic cardiomyopathy (4), Brugada syndrome (5).

There are numerous interconnecting collateral vessels between major coronary arteries in normal human hearts (6). Coronary collateral channels are not visible in patients with normal or mild coronary artery disease. However, they may become visible when a major coronary artery is occluded (7). Coronary collateral circulation has been recognized for a long time as an alternative source of blood supply to distal aspect of occluded coronary artery. A well-grown coronary collateral circulation may prevent development of transmural MI (8), chest pain and ECG sign of ischemia during a brief period of coronary occlusion in patients undergoing percutaneous coronary angioplasty, in patients with coronary artery disease (9) and even in entirely normal hearts (10).

We hypothesized that fQRS on ECG may be related with poorly developed collateral circulation in patients without prior MI.

Methods

Study design

Retrospective observational study.

Patients

Study group patients were retrospectively selected from a total of 2200 patients who underwent coronary angiography at our center between January 2008 and February 2010. Patients with a totally occluded major coronary artery were included. Following exclusion criteria were applied:

1. >1 occluded major coronary arteries
2. Distal vessel occlusions
3. History of previous MI
4. Pathological Q wave on ECG (≥ 0.04 seconds in duration and than 1/4 of the following R wave in voltage)
5. Hypertrophic or dilate cardiomyopathy
6. History of coronary artery surgery or percutaneous coronary intervention
7. Typical left bundle block or right bundle block on ECG (QRS duration>120 ms) and incomplete right bundle block (QRS duration <120 ms and RSR' patterns in V1- two precordial leads).

Coronary angiography and coronary collateral scoring

Coronary angiography was performed using Judkins technique. Evaluation of angiographies and collateral scoring was performed by two experienced cardiologists who were blinded to the study. Collateral circulation was graded according to Rentrop's classification (11): grade 0-no visible collaterals, grade 1-filling of side branch via collateral vessels without visible epicardial coronary artery, grade 2-incomplete filling of epicardial coronary artery, and grade 3-complete filling of epicardial coronary artery.

ECG criteria for fQRS

The fQRS was defined as the presence of an additional R wave (R') or notching of R or S wave or the presence of fragmentation (more than one R') in 2 contiguous leads corresponding to a major coronary artery territory. All ECGs were analyzed by two independent cardiologists blinded to study. There was 99.9% concordance for ECG sign of fQRS.

Study protocol was approved by ethics committee.

Statistical analyses

SPSS for Windows software was used for statistical analysis (SPSS Inc. Chicago, Illinois, USA). Categorical data are described as frequency and percentage. Continuous data are presented as mean±SD. We used Chi-square test, to test for differences in categorical factors between fQRS and non fQRS patients. Continuous variables were compared using unpaired Student's t-test. A p value <0.05 was considered statistically significant. Logistic regression analysis was performed to test whether presence of fQRS (dependent variable) predicts to Rentrop grades (independent variables).

Results

Of the 2200 consecutive patients who underwent coronary angiography at our institution, 154 had total occlusion of a single coronary vessel. Ninety-eight patients were excluded for the following reasons: 1) history of myocardial infarction or pathological Q wave on ECG (90 patients), 2) presence of typical bundle branch block (4 patients) and 3) presence of incomplete right bundle branch block (4 patients). The remaining 56 patients formed the study group (mean age 61.7±7.9; 68% man). All patients had a positive exercise stress test for myocardial ischemia. Twenty-two patients had fQRS on ECG.

The prevalence of various demographic, clinical and angiographic characteristics of the patients is summarized in Table 1.

There was no significant difference in baseline characteristics of the patients with and without fQRS.

All patients had coronary collateral circulation with different degrees and none of them had Rentrop grade 0. Fifteen (27%) patients had Rentrop grade 1, 15 (27%) patients had grade 2 and 26 (46%) patients had grade 3 collateral circulation. Of 26 patients with grade 3 collateral circulation, 5 patients (19%) had fQRS on ECG. Of 15 patients with grade 2 collateral circulation, 7 patients (47%) had fQRS on ECG. Of 15 patients with grade 1 collateral circulation, 10 patients (67%) had fQRS on ECG (p=0.002) (Table 2). Example of ECG - a patient who had grade 3 collateral circulation and LAD occlusion, is shown in Figure 1, while example of ECG of a patient who had grade 1 collateral circulation and RCA occlusion, is shown in Figure 2. Logistic regression analysis demonstrated that fragmented QRS is a significant predictor of CCC (odds ratio= 8.4; 95% CI 1.97-35.7; p=0.004) (Table 3).

Discussion

The principal finding of our study is that fQRS on standard 12-lead ECG was related with coronary collateral circulation in patients with chronic total occluded coronary artery and no history of previous MI.

The sensitivity, specificity and negative predictive value of fQRS for myocardial scar were reported to be 86%, 89% and 96% respectively (2). Fragmentation of the QRS complex has been explained by inhomogeneous activation of the myocardium due to myocardial scar or ischemia (12). Infarct size is inversely related with collateral circulation and directly related with the occlusion time (13). However, if patients had well-grown collateral circulation (collateral index >25%), occlusion time may not predict infarct size (14). There may be no infracted myocardium within the occluded artery territory in about half of patients with chronic total occlusion. These patients may remain completely asymptomatic (15). It has been reported that in patients with chronic total occlusion and no history of prior MI, presence of Rentrop grade 3 collateral flow prevents resting segmental wall motion abnormalities and perfusion defects as compared to Rentrop grade 1 and 2 (16). Also in another study, it has been shown that presence of collateral circulation may reduce the severity of ischemia during brief occlusion period in patients with isolated proximal LAD stenosis (17). Wustmann et al. (10) showed that coronary collateral circulation may prevent occurrence of sign of myocardial ischemia during brief coronary occlusion approximately in a fourth of normal human hearts. These data indicate that a well-grown and functioning coronary collateral circulation may prevent myocardial ischemia and MI in patients with total coronary occlusion. Because, only source of blood supply to the distal aspect of total occluded coronary artery is collateral circulation.

In our study, 5 (19%) patients who had Rentrop grade 3 collateral circulation had fQRS on ECG. However, 7 (47%) patients who had Rentrop grade 2, and 10 (67%) who had Rentrop grade 1 collateral circulation had fQRS on ECG. Logistic regression analysis showed that, patients with occluded major coronary artery and fQRS on ECG 8.4 times more likely to have grade1 collateral circulation.

This data may implicate that, a poorly grown collateral circulation may not protect against ischemia and probably occurrence of microinfarcts in the area at risk in patients with chronic total occlusion. Thus, poorly-grown collateral circulation may be responsible for depolarization abnormalities in these patients. Finally, in patients with poorly grown collateral circulation fQRS may present on ECG . Also it may be implicated that a well-grown collateral circulation prevents ischemia and micro infarctions in the area at risk. Myocardial scar in total occluded coronary artery territory can be shown by single photon emission computed tomography (SPECT) and cardiac magnetic resonance imaging. However, these imaging techniques are costly and also time consuming. Presence of fQRS on ECG may be used for prediction of myocardial scar and on another hand collateral circulation.

Table 1. Baseline characteristics of patients according to with and without fragmented QRS

Variables	fQRS (-)	fQRS (+)	p *
Age, years	60.3±7.8	63.9±7.9	0.103
Gender, male, n (%)	25 (73)	13 (55)	0.263
Hypertension, n (%)	22 (65)	12 (54)	0.451
Hyperlipidemia, n (%)	19 (56)	14 (64)	0.568
Diabetes mellitus, n (%)	7 (21)	7 (32)	0.348
Smoking, n (%)	16 (47)	8 (36)	0.434
BMI, kg/m^2	28±4.3	27±4	0.496

Data are presented as mean±standard deviation and numbers/percentages
*unpaired Student-t test and Chi-square test
BMI - body mass index, fQRS - fragmented QRS

Table 2. Incidence of fQRS in patients with Grade 1, Grade 2, and Grade 3 collateral circulation

Variables	fQRS(-)	fQRS(+)
Grade 1 CCC, n (%)	5 (33)	10 (67)
Grade 2 CCC, n (%)	8 (53)	7 (47)
Grade 3 CCC, n (%)	21 (81)	5 (19)
Total, n (%)	34 (61)	22 (39)

Data are presented as numbers/percentages
Chi-square test: Pearson Chi-square test= 9.442, p=0.002
CCC - coronary collateral circulation, fQRS - fragmented QRS

Table 3. Univariate logistic regression analysis for the presence of fQRS according to Rentrop grades

	B	Wald	odds ratio	95% CI	p
Grade 3 CCC		8.556	1	-	-
Grade 2 CCC	1.302	3.286	3.7	0.9-15.01	0.07
Grade 1 CCC	2.128	8.271	8.4	1.97-35.7	0.004

CCC - coronary collateral circulation, CI - confidence interval, fQRS - fragmented QRS

Figure 1. Example of grade 3 collateral circulation is shown in top panel (coronary angiography view during right coronary artery injection). Example of ECG of the same patient in top panel is shown in bottom panel; note, there are no pathological Q-waves or fQRS in anterior leads (V1-V6)

ECG - electrocardiogram

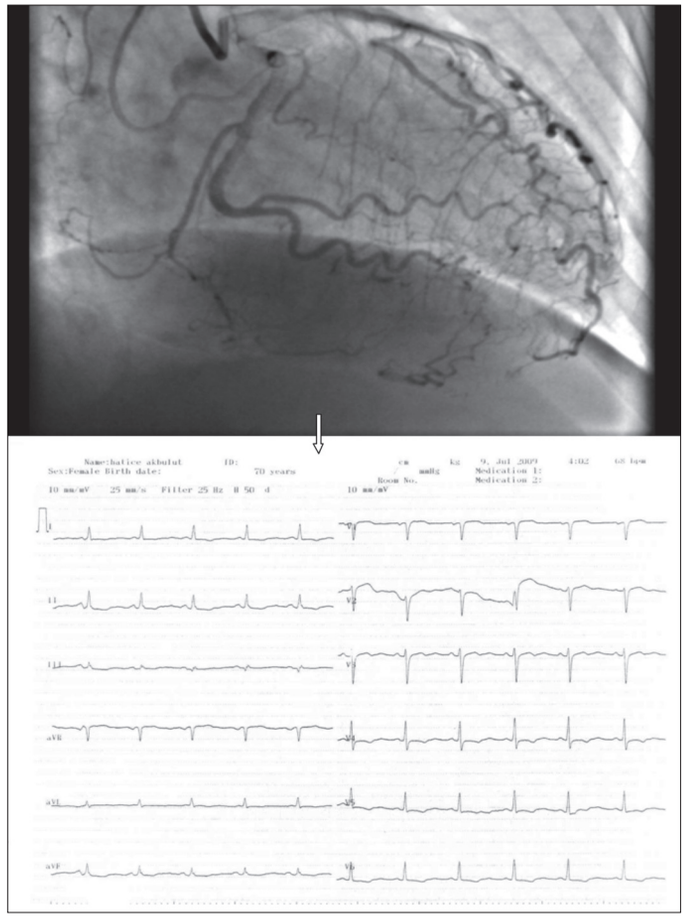

Figure 2. Example of grade 1 collateral circulation is shown in top panel (coronary angiography view during left coronary artery injection). Example of ECG of patient in top panel is shown in bottom panel; there are fQRS in inferior leads (D2-D3-aVF)

ECG - electrocardiogram

Study limitations

Several limitations should be considered. This study is subject to the limitations inherent to a retrospective study. A second limitation of the study is the small sample size. Because of, our study is consisting of selected cases. Finally, absence of qualitative measure of myocardial scar such as myocardial SPECT and cardiac magnetic resonance imaging is the another limitation. Further studies with larger numbers and qualitative measure of myocardial scar are needed to better clarify this issue. We used to univariate logistic regression analysis and does not include in the model for potential confounding variables. This is another potential limitation. Further studies, with larger number of patients and use of multivariable logistic regression analyses to confirm the independent of other confounding variables predictive value of fQRS are needed.

Conclusion

Results of our study indicate that the presence of fQRS on ECG is predictor of a poorly grown coronary collateral circulation in patients with chronic total coronary occlusion and no history of prior MI. Fragmented QRS in these patients may be related with ischemia and/or micro infarcts within occluded vessel territory.

Conflict of interest: None declared.

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