Regression of Q Waves and Clinical Outcomes After Primary Percutaneous Coronary Intervention in St Elevation Myocardial Infarction

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ABSTRACT

Introduction: Pathological Q waves are correlated with infarct size, and Q wave regression is associated with left ventricular ejection fraction improvement. There are limited data regarding the association between Q wave regression and clinical outcomes. Our main objective was to assess the association of pathological Q wave evolution after reperfusion with clinical outcomes after ST-elevation myocardial infarction (STEMI).

Patients and Methods: Standard 12-lead electrocardiograms (ECGs) were recorded in 1553 patients, who presented to our hospital with chest pain and underwent primary percutaneous coronary intervention (p-PCI) with the diagnosis of STEMI and were retrospectively analyzed. ECGs were recorded before and 90 min after PCI, as well as at hospitalization discharge and 12 months of follow-up. The study population was divided into three groups as the Q wave regression group, the Q wave persistent group, and the non-Q wave MI group.

Results: There were 502 (32%) patients with persistent Q waves (PQ group), 509 (33%) patients with Q wave regression (RQ group), and 542 (35%) patients with non-Q wave MI (NQ group). The degree of LVEF was significantly greater in the RQ group and NQ group than in the PQ group [(47.5 ± 10.1 vs. 49.2 ± 9.9) vs. 43.3 ± 10.5 respectively, p< 0.01]. One-year mortality was significantly greater in the PQ group compared to the RQ and NQ groups [19 (3.78%) vs. 11 (2.16%) vs. 6 (1.1%) respectively, p< 0.01].

Conclusion: In a population of STEMI patients, persistent Q waves defined according to the classic ECG criteria after reperfusion were associated with high one-year mortality, and low LVEF, while Q wave regression was associated with significantly lower risk of events.

Key Words: ST-elevation myocardial infarction; Q wave regression; primary percutaneous coronary intervention

ST Yükselmeli Miyokard İnfarktüsünde Primer Perkütan Koroner Girişim Sonrası Q Dalgalarının Gerilemesi ve Klinik Sonuçları

ÖZET

Giriş: Patolojik Q dalgaları enfarktüs boyutuyla, Q dalgası gerilemesiyse daha iyi sol ventrikül ejeksiyon fraksiyonuyla ilişkilidir. Q dalgası gerilemesi ve klinik sonuçları arasındaki ilişki hakkında sınırlı veri vardır. Çalışmamızın temel amacı, reperfüzyon sonrası patolojik Q dalgası değişiminin ST yükselmeli miyokard infarktüsü (STEMI) sonrası klinik sonuçlarla ilişkisini değerlendirmektir.

Hastalar ve Yöntem: Hastanemize göğüs ağrısıyla başvuran ve STEMI tanısıyla primer perkütan koroner girişim (p-PCI) uygulanan 1553 hastanın standart 12-lead elektrokardiyogramları (EKG) geriye dönük olarak incelendi. p-PCI'dan önce ve 90 dakika sonra, hastaneden taburculuk sırasında ve 12 aylık takibin sonundaki hasta EKG'leri kaydedildi. Çalışma popülasyonu Q dalga regresyon grubu (RQ), kalıcı Q dalga grubu (PQ) ve Q dalgası oluşmayan grup (NQ) olmak üzere üç gruba ayrıldı.

Bulgular: PQ grubunda 502 (%32), RQ grubunda 509 (%33) ve NQ grubunda toplam 542 (%35) hasta vardı. LVEF derecesi RQ grubunda ve NQ grubunda PQ grubuna göre anlamlı olarak daha yüksekti [sırasıyla (47.5 ± 10.1 vs. 49.2 ± 9.9) ve (43.3 ± 10.5), p< 0.01]. Bir yıllık mortalite, PQ grubunda RQ ve NQ gruplarına kıyasla anlamlı olarak daha yüksekti [sırasıyla 19 (3.78 %) vs. 11 (2.16 %) ve 6 (1.1%), p< 0.01].

Sonuç: STEMI hasta popülasyonunda, reperfüzyon sonrası klasik EKG kriterlerine göre tanımlanan kalıcı Q dalgaları yüksek bir yıllık mortalite ve düşük LVEF ile ilişkiliyken, Q dalgası gerilemesi önemli ölçüde daha düşük kardiyovasküler olay riskiyle ilişkiliydi.

Anahtar Kelimeler: St yükselmeli miyokart enfarktüsü; Q dalga gerilemesi; primer perkütan koroner girişim

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INTRODUCTION

The most prominent diagnostic tool used for the identification and treatment of acute ST-elevation myocardial infarction (STEMI) is the 12-lead electrocardiogram (ECG). Patients presenting with acute coronary syndrome are classified as STEMI or non-STEMI (NSTEMI) as determined by ECG[1,2]. A classic sign of necrosis on the ECG is pathological Q waves representing non-depolarized areas of the myocardium[3-5]. If Q waves lasted more than 0.03 seconds, they were classified as pathological by TIMI (Thrombolysis in Myocardial Infarction) investigators according to Selvester criteria[6]. The Selvester QRS score on surface ECG has prognostic value in various cardiac events related to myocardial scarring. Recently Karakus et al.[7] demonstrated that the Selvester QRS score on surface ECG can predict re-hospitalization due to ischemic heart failure (HF). Previous studies have shown that patients demonstrating Q wave regression develop a smaller infarct area and better left ventricular (LV) wall motion[8-11]. Most data on the importance of the Q wave in STEMI were obtained before the reperfusion period. Data showing Q wave regression clinical significance in the post-reperfusion period with percutaneous coronary intervention (PCI) are limited. Post-reperfusion ECG is frequently overlooked in routine clinical practice and is rarely taken into account in treatment management when clinical indicators are absent. Currently, reports have shown that Q wave regression following reperfusion correlates with left ventricular ejection fraction (LVEF) recovery and a reduction in infarct size as evidenced by serial cardiac magnetic resonance imaging (MRI)[12]. In this study, we aimed to evaluate the effect of pathological Q wave development on one-year clinical outcomes in STEMI patients treated with primary-PCI (p-PCI).

PATIENTS and METHODS

Patient Population

In this report, 2394 patients who were hospitalized with STEMI and underwent p-PCI between January 2019 and September 2021 were retrospectively analyzed. Inclusion criteria for the study were as follows;

1) No history of myocardial infarction (MI);

2) No LV hypertrophy, Wolff-Parkinson-White syndrome, bundle branch block (BBB), or intraventricular conduction disorder;

3) Identified infarct-related lesion;

4) No thrombolytic therapy before emergency coronary arteriography;

5) Acceptable ECG recordings;

6) No subsequent MI, coronary angioplasty, or bypass surgery during one-year follow-up. Finally, the study was completed with a total of 1553 patients (1149 men and 404 women) who met the criteria. Basic demographic/clinical data were collected by telephone interviews and medical history. Patients who underwent p-PCI with stent implantation within 12 hours of symptom onset were also included. After hospital admission, the patients were given a single dose of clopidogrel (600 mg) and aspirin (300 mg). Unfractionated heparin (1st dose: 5000-10000 I.U., additional doses: achieve clotting time> 250 seconds) was adjusted according to operator preference. The patients were admitted to the coronary care unit after angioplasty and were given routine anti-thrombotic therapy of aspirin (100 mg) and clopidogrel (75 mg) daily. The study design was presented to the local ethics committee of our hospital and the necessary approval was obtained.

Echocardiography Analysis

All patients underwent transthoracic echocardiography (TTE) (Vivid 7; GE Medical System, Horten, Norway) during the first-year visit, and LVEF was determined using the Simpson's method. The data of patients who died within one year were based on the last TTE recorded in the system.

Based on the medical records, ECGs of all patients were recorded at admission, 90 minutes after PCI, and the first-year visit. For patients who died within the last year, the most recent ECGs recorded in the system were taken as a basis. A standard 12-lead ECG was logged at 25 mm/sec and calibrated at 10 mV/mm. The results of the ECGs were examined by two independent experts who were blinded to the groups. In case of disagreement over the interpretation of a particular ECG, the trace was reviewed together. Q waves were scored for each ECG using the classical criteria: The presence of a Q wave of ≥40 ms duration and/or a depth of ≥25% of the R wave in the same lead or the presence of a Q wave equivalent[12]. Therefore, subjects were divided into three groups based on the ECG analyses:

1) Non-Q group (NQ group): Without Q waves on 90-minute ECG, discharge, and one-year follow-up.

2) Persistent Q group (PQ group): Same or increased number of Q waves on 90-minute ECG, discharge, and one-year follow-up.

3) Q wave regression group (RQ group): Decreased number of Q waves on 90-minute ECG, discharge, and one-year follow-up.

Statistical Analysis

R statistics for software Windows R version 4.02 (Vienna, Austria) were used for statistical analysis. All number values were expressed as median and interquartile range, while nominal values were expressed as numbers and percentages. Chi-square and Fisher's exact tests were performed to compare

categorical variables. A One-Way ANOVA was performed to evaluate continuous variables with normal distribution. Continuous variables that did not show normal distribution were subjected to a Kruskal Wallis test. All tests were two-tailed and a p-value of less than 0.05 was considered statistically significant.

RESULTS

All subjects (n= 1553) that met the inclusion criteria for the study were enrolled. The group distribution was as follows: 502 (32%) patients in the PQ group, 509 (33%) patients in the RQ group, and 542 (35%) patients in the NQ group. Table 1 shows the basic demographic, clinical, and laboratory characteristics of the groups according to the Q wave regression. No difference was found between groups based on age, multi-vessel and smoking status, DM, HT, HL anemia, previous CABG, and COPD. WBC [13.3 (5.8) vs. 12 (4.1) vs. 10.9 (3.4) respectively, p< 0.01] and CRP [6.7 (3.7) vs. 4.4 (3.2) vs 4.6 (3.5) respectively, p< 0.01] were higher in patients in the RQ and PQ groups than the NQ group (Table 1). Tirofiban use was greater in patients in the RQ and PQ groups than in the NQ group [246 (48.3) vs. 271 (54%) and 241 (44.5%), p< 0.01]. The Killip classification at admission was greater in the PQ group in comparison to the RQ and NQ groups [46 (9.2%) and 16 (3.1%) and 12 (2.2%), respectively, p< 0.01)]. The LVEF grade was higher in the RQ and NQ groups compared to the PQ group [47.5 (10.1) and 49.2 (9.9) and 43.3 (10.5), respectively, p< 0.01]. CIN frequency was higher in PQ compared to

Table 1. Demographic, clinical, and laboratory properties of the groups according to the q wave regression

Characteristics	Non-Q Wave (n= 542)	Q Wave Regression (n= 509)	Persistent Q Wave (n= 502)	p
Gender (male), n (%)	380 (70.1)	372 (73.1)	397 (79.1)	0.04
GFR≤ 60 mL/min/1.73 m^2, n (%)	41 (7.6)	42 (8.2)	68 (13.5)	0.002
DM, n (%)	148 (27.3)	133 (26.1)	142 (28.3)	0.74
HT, n (%)	156 (28.8)	125 (24.6)	113 (22.5)	0.58
Anemia, n (%)	167 (30.8)	133 (26.1)	145 (28.9)	0.24
Smoking, n (%)	180 (33.2)	155 (30.5)	135 (30.9)	0.58
HL, n (%)	155 (28.9)	131 (25.7)	114 (22.7)	0.09
COPD, n (%)	23 (4.2)	21 (4.1)	26 (5.2)	0.67
Previous stroke, n (%)	7 (1.3)	3 (0.6)	5 (1)	0.50
Killip class 3 or 4, n (%) n (%)	12 (2.2)	16 (3.1)	46 (9.2)	<0.01
Previous CABG, n (%)	4 (0.7)	5 (1)	11 (2.2)	0.87
CIN, n (%)	23 (4.2)	27 (5.3)	50 (10)	<0.01
Tirofiban use, n (%)	241 (44.5)	246 (48.3)	271 (54)	0.009
Multivessel disease, n (%)	111 (20.5)	99 (19.4)	94 (18.7)	0.77
Age (years)	56 ± 11	56 ± 11	57 ± 11	0.23
WBC (10^3/μL)	10.9 ± 3.4	12 ± 4.1	13.3 ± 5.8	<0.01
Total cholesterol (mg/dL)	175.7 ± 39.3	178.5 ± 43.4	177.9 ± 48.1	0.90
TG (mg/dL)	161.1 ± 113.3	157.4 ± 86.2	158.1 ± 100.2	0.47
LDL (mg/dL)	110.4 ± 37.1	110.2 ± 38.3	105.5 ± 37.6	0.06
HDL (mg/dL)	38.6 ± 11	36.9 ± 9.3	37.8 ± 10.1	0.07
CRP (mg/L)	4.6 ± 3.5	4.4 ± 3.2	6.7 ± 3.7	<0.01
LVEF (%)	49.2 ± 9.9	47.5 ± 10.1	43.3 ± 10.5	<0.01
1-year mortality, n (%)	6 (1.1)	11 (2.16)	19 (3.78)	<0.01

CABG: Coronary artery bypass grafting, CIN: Contrast-induced nephropathy, COPD: Chronic obstructive pulmonary disease, CRP: C-reactive protein, DM: Diabetes mellitus, LVEF: Left ventricular ejection fraction, GFR: Glomerular filtration rate, HT: Hypertension, HL: Hyperlipidemia, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, PCI: Percutaneous coronary intervention, TG: Triglyceride, WBC: White blood cell.

RQ and NQ groups [50 (10%) and 27 (5.3%) and 23 (4.2%), p< 0.01, respectively]. One-year mortality was higher in PQ compared to RQ and NQ groups [19 (3.78%) and 11 (2.16%) and 6 (1.1%), p< 0.01, respectively].

DISCUSSION

The key findings of the study were as follows:

1) Q wave regression was present in almost half of the patients at post-reperfusion and the time of the first year follow-up;

2) LV functionality was significantly better at one-year in the RQ group than in the PQ group;

3) The risk of death in one year was three times greater in the PQ group than the NQ group, while subjects in the RQ group had a better prognosis;

4) The evolution of the Q wave over time remains an important determinant of clinical outcomes in the post-MI period.

Several large clinical studies are showing that both persistence and absence of the Q wave are the main determinants of infarct size and clinical outcome in STEMI patients[4,8,13,14]. In a recent study, Q waves were found to be the main determinant of in-hospital mortality in STEMI[15]. The presence of Q waves in the infarct leads in the presence of STEMI independently predicted higher 30-day mortality in patients treated with fibrinolytics[16]. Also, Q wave regression correlates with less necrotic myocardium and an improved LV diastolic and systolic function[9]. In our study, we found that LVEF was higher in the RQ group compared to the PQ group as determined by conventional echocardiography, which validates our previous findings. Ventricular remodeling is a process characterized by changes in the size, shape, and functions of the ventricle, which occurs as a result of myocardial damage. Myocardial infarction leads to complex changes in ventricular anatomy. Dilatation and thinning of the infarction zone, hypertrophy of normal regions, and dilatation are monitored. These changes begin in the early stages of myocardial infarction and continue progressively. The most important clinical determinants of remodeling are the width of the infarction area, the localization of infarction, and the patency of the infarct-related artery. It is known that patients with reduced LV remodeling have better preservation of LVEF and functional capacity. This directly leads to improved outcomes and reduced all-cause mortality. Early diagnosis of LV remodeling is important for planning the treatment of patients with MI. Therefore, it is extremely important to identify early determinants of LV remodeling, diagnose them with non-invasive, simple, reliable methods, and treat them aggressively. Less LV remodeling and smaller infarct size, often with features of reduced tissue damage, may be the mechanism essential for clinical outcome improvement in the RQ group. The size of the infarct is a critical determinant of all-cause mortality and HF events in STEMI patients who underwent p-PCI[17]. A recent Cardiac Magnetic Resonance (CMR) study showed that Q wave regression was associated with less ventricular remodeling, smaller infarct size, and better functional myocardial recovery compared to persistent Q waves[12]. Current guidelines recommend using the following parameters to adjust the medical management of patients following MI: LVEF; the presence and extent of coronary atherosclerotic lesions; heart failure clinic; and accompanying comorbid diseases[18]. ECG is a non-invasive, simple, and practical test in clinical practice. However, its significance is underestimated after STEMI and is not taken into account in the management of treatment, especially in the absence of clinical symptoms. According to our findings, a follow-up ECG has the potential to inform different treatment options as a categorization tool in STEMI patients. As we mentioned in our methodology, categorizing post-STEMI patients as NQ, PQ, or RQ MI can determine management and individualize progression after MI. Patients with Q wave regression after STEMI may benefit from the simplification of pharmacological therapy. On the contrary, persistent Q wave patients may be offered additional pharmacological support, new treatments, ICD (implantable cardioverter defibrillators)/CRT (cardiac resynchronization therapy) conversations, and reduced periods of follow-up. More randomized clinical trials are recommended to help evaluate the potential clinical utility of ECG as a classification tool in STEMI patients undergoing p-PCI.

Limitations

Our study has some limitations. Primarily our study was a retrospective cohort study. Secondly, one hundred ninety-eight subjects were not enrolled because of confounding factors as mentioned above, representing 8.2% of the entire patient population excluded. Thus, we conclude that our study may have a selection bias. Apart from standard routine practice, no specific ECG recording protocol was used for electrode placement, which may give rise to variability that affected our results. Finally, the lack of CMR imaging for the assessment of infarct size is another limitation.

CONCLUSION

In our study, Q wave regression was associated with significantly better LVEF and mortality rates at one-year in STEMI patients treated with p-PCI. The use of a follow-up ECG in patients with STEMI may assist in treatment decisions and personalization of post-MI treatment. More research is recommended to evaluate the possible clinical utility of a 12-lead ECG as a classification tool in STEMI patients undergoing p-PCI.

Ethics Committee Approval: The approval for this study was obtained from Kartal Koşuyolu High Specialization Training and Research Hospital Ethics Committee (Decision no: 2022/3/571, Date: 08.02.2022).

Informed Consent: This is retrospective study, we could not obtain written informed consent from the participants.

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