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Correlation Between The Number of Pathological Q waves and Left Ventricular Ejection Fraction Among Patients with ST-Segment Elevation Myocardial Infarction

Hootan Manhoobi [1], Mehdi Sheibani [1], Maryam Taherkhani [1], Saeid Shahraz [2], Mohammad Reza Beyranvand *[1]

[1] Department of Cardiology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[2] Tufts Medical Center, Boston, MA, United States.

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ABSTRACT

Introduction: Pathological Q waves in an electrocardiogram (ECG) are robust prognostic markers in patients with ST-segment elevation myocardial infarction (STEMI), a leading global cause of death. Accurately identifying high-risk patients with STEMI is essential to provide tailored management, thereby improving patient outcomes. Thus, this study aims to evaluate the relationship between the number of leads with pathological Q wave in the first ECG and left ventricular ejection fraction (LVEF) before discharge.

Methods: This retrospective study reviewed the records of 152 STEMI patients meeting inclusion criteria at Taleghani Hospital from April 2014 to August 2018. The initial ECGs, angiography, and echocardiography data were extracted, read by cardiologists, and prepared for analysis.

Results: The majority of patients (87.5%) were males, and 69.7% had a pathological Q wave at the first ECG. The median of LVEF was significantly lower in patients with a pathological Q wave than in patients without a pathological Q wave (45 versus 50, p-value < 0.001). In addition, there was a mild negative correlation between the number of pathological Q waves and LVEF (r = -0.318, p-value < 0.001).

Conclusions: This study reveals the presence of a mild negative linear relationship between LVEF and the number of pathological Q waves in STEMI patients.

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Introduction

Cardiovascular disease (CVD) is recognized as the leading cause of death and disability worldwide. Globally, deaths from CVD are increasing due to combined effects like population aging and growth. According to the Centers for Medicare & Medicaid Services Hospital Inpatient Quality Reporting Program data on 2363 hospitals in 2018, the average 30-day mortality after an acute myocardial infarction (AMI) was 13.6%, with higher mortality observed in rural hospitals (1,2).

A common type of AMI is ST-segment elevation myocardial infarction (STEMI).

* Corresponding authors: Mohammad Reza Beyranvand, Department of Cardiology, Taleghani Hospital, Velenjak Street, Shahid Chamran Highway, Tehran, Iran. 1985711151; Tel: +989121348366; E-mail address: beyran4@yahoo.com .

During STEMI, "time is muscle." The longer the infarct time, the greater the ischemia and subsequent necrosis of the myocardium (3,4). Thus, STEMI is a medical emergency and requires immediate care to achieve narrow timeliness guidelines for myocardial reperfusion via fibrinolytic therapy or primary percutaneous coronary intervention (PCI) (4-6). The only paraclinical investigation before reperfusion therapy is often an electrocardiogram (ECG) with criteria such as new ST-segment changes, new bundle branch block, or the presence of pathological Q waves for diagnosing the AMI. Therefore, clinical outcomes of patients are predicted based on ECG alone because it is a non-invasive technique, readily available, and economical (6-9).

Pathological Q waves that may be observed during an AMI indicate abnormal negative deflection in the ECG and signify a significant electrical abnormality in the heart. The formation of pathological Q waves is often attributable to myocardial necrosis, hibernation, and stunning, all known to cause ventricular contractile dysfunction (10). In addition, as abnormal Q waves are a common finding early in AMI (11), they may provide an independent prognostic marker of a clinical outcome (12) and one-year mortality (13).

Identifying the highest-risk patients with STEMI is essential for providing individually focused management and improving prognosis (7). In this way, the predictive value of Q waves may give physicians an additional tool to improve STEMI care and outcomes without additional cost or delay. Therefore, this study aims to assess the correlation between the number of leads with pathological Q wave in the first ECG and left ventricular ejection fraction (LVEF) before the discharge time.

Material and Methods

Study design

This retrospective, cross-sectional study was conducted between April 2014 and August 2018. The Ethics Committee of Shahid Beheshti University of Medical Sciences (SBMU) approved the study. For development, this study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline (14).

Setting

The study took place at the Department of Cardiology at the Taleghani Hospital, located north of Tehran, affiliated with SBMU. The catheterization laboratory of the Taleghani Hospital is not a 247 (doing primary PCI 24 hours 7 days) center.

Participants

Patients of both genders over 20 years of age who experienced STEMI according to the fourth universal definition of MI (8) consecutively were included in this study. In addition to inclusion, all patients should have an initial ECG taken before any procedure and an LVEF taken during hospitalization. To reach these appropriate patients, we reviewed the hospital records of 440 patients tagged with AMI from the archive list of the hospital. After excluding the patients who did not meet the inclusion criteria, 152 remained for statistical analysis (Figure 1).

Data sources/ measurement

All files were reviewed, and information such as identity information, drug history, past medical history, laboratory, echocardiography, and outcomes were extracted and recorded separately for each case in the electronic sheet. Initial ECG images (standard, right, and posterior) were taken from ECG's paper and documented in archive files separately for each case. Angiography/angioplasty film of each case, if available, was extracted from the hospital's catheterization laboratory archive.

Electrocardiographic Evaluation

Two cardiologists blinded to the patient's name read the good-quality ECG images and recorded the data for each subject on a sheet. All 12-lead ECGs were taken with a standard speed of 25 mm/s and a 10 mm/mV voltage. The definition of pathological Q waves was according to the fourth universal definition of MI as follows: any Q wave in leads V2–V3 > 0.02 second or QS complex in leads V2 –V3; or Q wave ≥ 0.03 second and ≥ 1 mm deep or QS

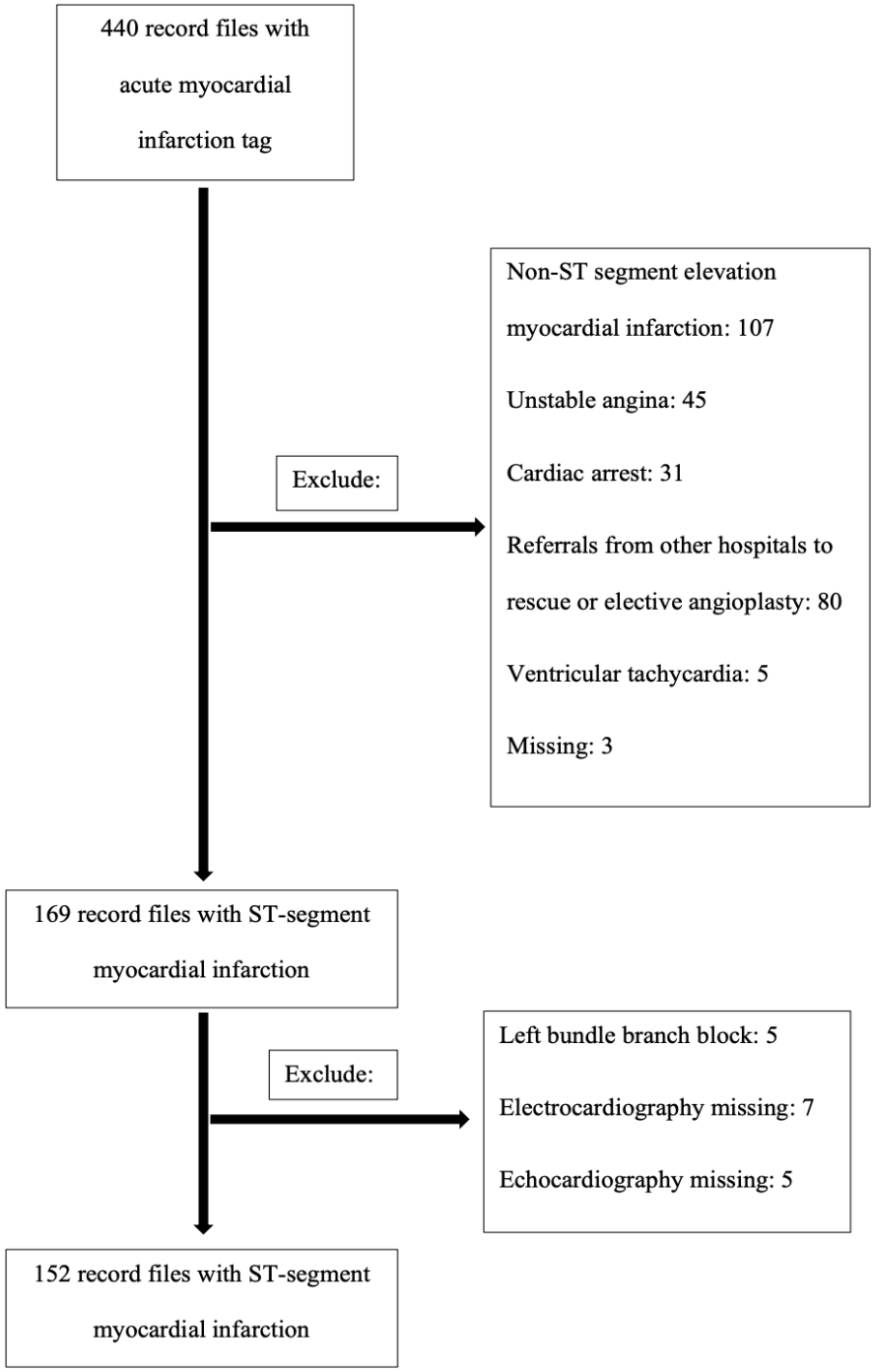

Figure 1. Flow chart of the patients included in the study.

complex in leads I, II, aVL, aVF or V4–V6 in any two leads of a contiguous lead grouping (I, aVL; V1–V6; II, III, aVF) (8).

The depth and width of ECG variables were not measured in this study and were only examined for their presence. Therefore, the total number of leads in which pathological Q waves were present was obtained for each case.

The localization of MI was categorized as anterior (ST-segment elevation in leads V1–V6), inferior (leads II, III, aVF), lateral (leads I, aVL, and/or V5–V6), posterior (leads V7–V8) and leads V3R-V6R for right MI.

Angiography/angioplasty evaluation

A cardiologist read the angiography/angioplasty film of each case. Then, the data was recorded in the sheet for each case.

Statistical methods

All statistical analyses were conducted using SPSS software version 24.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean and standard deviations (SD) for data that was not skewed or median (25th percentile - 75th percentile) for skewed data. Categorical variables were expressed as the frequency with percentage. The Mann-Whitney test was used for non-normal distributed data. Categorical variables were compared using the Chi-square test. Spearman's rank correlation coefficients were used to evaluate associations between LVEF and the number of Q waves. Statistical significance is obtained when p-value < 0.05.

Results

Table 1 shows the demographic and clinical characteristics of the patients at baseline.

There were 133 (87.5%) males and 19 (12.5%) females, with an age range of 25-89 years, with a mean of 57.51 ± 11.47 years in men and 63.58 ± 13.20 years in women.

In angiographic analysis among 108 available cases, the initial thrombolysis in myocardial infarction (TIMI) grade flow of 0 (no perfusion) and 1 (penetration without perfusion) was observed in 69 (63.8%) cases.

The left anterior descending artery (LAD) was the most common culprit lesion in about half of the 112 cases (Table 1).

Table 1. Demographic and clinical characteristics of the patients at baseline. *

Variables		Total (N=152)
Age — yr		
	Mean	58.27 ± 11.83
	Women ≤ 55 yr — no. (%)	7 (4.6)
	Men ≤ 45 yr — no. (%)	18 (11.8)
Male sex — no. (%)		133 (87.5)
Past medical history — no. (%)		
	Hypertension	60 (39.5)
	Diabetes mellitus	36 (23.7)
	Current smoker	70 (46.1)
Outcomes — no. (%)		
	Leave the hospital with the consent	23 (15.1)
	Discharge	121 (79.6)
	Death	8 (5.3)
Echocardiography		
	LVEF — median (IQR)	47.5 (40-50)
	LVEF ≤ 35% — no. (%)	23 (15.13)
Treatment strategy — no. (%)		
	Thrombolytic	52 (34.2)
	Primary PCI	67 (44.1)
Culprit lesion — no./total no. (%)		
	LAD	51/112 (45.5)
	LCX	18/112 (16.1)
	LM	3/112 (2.7)
	PLV	3/112 (2.7)
	Diagonal	2/112 (1.8)
	SVG on RCA	1/112 (0.9)
	SVG on OM	3/112 (2.7)
	RCA	29/112 (25.9)
	PDA	2/112 (1.8)

* Plus-minus values are means ±SD. Percentages may not total 100 because of rounding. IQR denotes interquartile range, LAD left anterior descending, LCX left circumflex, LM left main, LVEF left ventricular ejection fraction, OM obtuse marginal, PCI percutaneous coronary intervention, PDA posterior descending artery, PLV posterior left ventricular, RCA right coronary artery, SD standard deviation, SVG saphenous vein graft.

Sixteen cases treated with thrombolytic did not respond to therapy and underwent rescue PCI.

Coronary stents were applied to 82 of 101 cases (81.2%).

The final TIMI grade flow of 2 (partial perfusion) and 3 (complete perfusion) was observed in 92 of 94 cases (97.8%).

Elevated qualitative or quantitative troponin levels, detected through a blood test, are essential criteria for diagnosing acute myocardial infarction (AMI) (7). In all cases reviewed, the troponin levels were found to be positive or weakly positive before or during hospitalization.

In ECG analysis, Table 2 shows electrocardiography characteristics.

About half of the cases were anterior (mixed and isolated) STEMI, and the rest were inferior (mixed and isolated) STEMI (Table 2)—also, the pathological Q wave presence in 106 (69.7%) patients.

Table 3 compares cases with the presence of pathological Q wave and without the presence of pathological Q wave. The median of LVEF was significantly lower in cases with the pathological Q wave than in patients without the pathological Q wave (45 versus 50, p-value < 0.001). Also, the number of patients who had LVEF ≤ 35% was significantly higher in patients with pathological Q wave than in patients without pathological Q wave (20.8% versus 2.2%, p-value = 0.002) (Table 3).

The correlation assessment between the number of leads with pathological Q wave and LVEF showed a mild negative correlation between these parameters (r = -0.318, p-value < 0.001). A mild negative correlation existed between the number of leads exhibiting pathological Q waves in ST elevation leads and LVEF (r = -0.275, p-value < 0.001).

Discussion

The main finding in this study is a mild inverse correlation between LVEF and the number of leads with pathological Q wave among patients with STEMI.

As mentioned earlier, pathological Q waves in an ECG indicate abnormal negative deflections and often show myocardial necrosis (10).

Table 2. Electrocardiography characteristics. *

Variables		Total (N=152)
Rate		75.3 ± 16.78
Rhythm — no. (%)		
	Normal sinus	127 (83.6)
	Sinus tachycardia	7 (4.6)
	Sinus bradycardia	16 (10.5)
	Sinus arrhythmia	2 (1.3)
Axis — no. (%)		
	Normal	134 (88.2)
	Left deviation	16 (10.5)
	Right deviation	2 (1.3)
Location of STEMI — no. (%)		
	Anterior	58 (38.2)
	Posterior	1 (0.7)
	Lateral	5 (3.3)
	Inferior	54 (35.5)
	Inferolateral	22 (14.5)
	Anteroinferior	3 (2)
	Anterolateral	8 (5.3)
	Complete	1 (0.7)
RBBB — no. (%)		6 (3.9)
Presence of pathological Q wave — no. (%)		106 (69.7)

* Plus-minus values are means ±SD. Percentages may not total 100 because of rounding. RBBB denotes right bundle branch block, SD standard deviation, STEMI ST-segment elevation myocardial infarction.

Furthermore, an increase in the number of ST-segment elevations signifies a greater area affected during myocardial infarction (8), while a decrease in LVEF typically corresponds to a higher degree of heart damage (6). These observations may explain the inverse relationship between LVEF and the number of leads with pathological Q waves.

Daniel C. Lee et al. studied 551 patients with prior AMI and used cardiac magnetic resonance imaging to estimate infarct size and measured LVEF. He found a significant continuous relationship between infarct size (also with LVEF) and the number of leads affected by pathological Q wave (9).

In our study, patients with pathological Q wave have lower LVEF than patients without pathological Q wave, similar to previous studies (10,15-18).

Also, we found that the prevalence of baseline pathological Q waves was about 70%, higher than previously reported in large clinical trials of primary PCI in STEMI (e.g., 56% in the APEX-AMI trial (12) and 46% in the PLATO trial (13)).

Most studies on pathological Q waves focused on outcomes and showed pathological Q waves on ECG are associated with adverse cardiovascular effects, including higher mortality (12,13,16,17,19). In a related article, Kimmo Koivula compared the role of Q and T waves in 627 patients with STEMI and concluded that Q waves were associated with larger infarcts and T-wave inversion with longer treatment delays. Furthermore, the patients with both Q and T wave inversion had the highest one-year mortality (20).

Some other articles investigated pathological Q wave and regression of pathological Q wave associated with cardiovascular outcomes. For example, in related articles, Yoni de Framond showed that in 780 anterior STEMI patients treated with primary PCI, persistent Q waves defined according to the classic ECG criteria after reperfusion were associated with a 4-fold increase in mortality (21). Also, Delavi et al. concluded that Q-wave regression is associated with the most significant improvement of LVEF in the study with 184 STEMI patients treated with PCI (22).

Studies focusing on the relationship between the number of pathological Q waves and LVEF are limited, and more research is needed in this area.

Limitation

One of the significant limitations of this study was extracting the data retrospectively, which means the degree of echocardiography operator, the measurement of the LVEF method, and the device brand needed to be clarified. Also, the ECGs were taken by various devices, which may affect our study results.

The other limitation of our study was that most of the patients were male (87.5%), resulting in an underrepresentation of female patients. Nevertheless, women constituted 26% to 30% of patients in various international registries (1,7) and Iran (23).

Conclusion

Pathological Q wave at baseline ECG is a common finding related to lower LVEF. In addition, there is a mild negative linear relationship between LVEF and the number of pathological Q waves in patients with STEMI.

Table 3. Comparison between cases with and without the presence of pathological Q wave. *

Valuable	With pathological Q wave (n=106)	Without pathological Q wave (n=46)	P-Value
Age — yr	59.07 ± 12.050	56.43 ± 11.224	0.209
LVEF — median (IQR)	45 (37.5-50)	50 (45-50.625)	< 0.001
LVEF ≤ 35% — no. (%)	22 (20.8)	1 (2.2)	0.002
Mortality — no. (%)	5 (4.7)	3 (6.5)	0.647

* Plus-minus values are means ± SD. IQR denotes interquartile range, LVEF left ventricular ejection fraction, NS not significant, SD standard deviation.

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