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Predictive Implication of Initial Electrocardiogram and Creatine Kinase for Left Ventricular Ejection Fraction in Patients with Acute ST-Elevation Myocardial Infarction

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Abstract

Aim: Our aim was to determine the clinical, electrocardiographic (ECG) and biochemical predictors of left ventricular dysfunction in patients with acute ST elevation myocardial infarction (STEMI).

Methods: Patients with STEMI admitted in Loghman Hakim hospital were studied. The ECG variables were: ECG rate, ECG rhythm, QRS duration, sum of absolute ST deviation (in all, inferior and anterior leads), number of leads with ST elevation, maximum ST elevation, presence of pathological Q waves and location of the infarct. The primary outcome measure was LVEF \leq 40%.

Results: A total of 124 patients (91 male, 33 female) were studied. Mean age of the patients was 59.1 years (SD=12.6). Of these, 52 patients (44.4%) had an LVEF \leq 40% and angiography was recommended to 68 patients (54.8%) at the time of discharge. The multivariate analysis showed an association of LVEF \leq 40% with prior MI, diabetes, maximum creatine kinase (CK) levels, the sum of absolute ST deviation in all and inferior leads.

Conclusions: The initial ECG and CK levels in patients with STEMI may contain valuable information for risk stratification, determination of prognosis and the subsequent management plan. The results of this study warrant further studies to define patients who benefit most from invasive and sophisticated interventions.

Keywords: Myocardial infarction; Electrocardiography; Creatine kinase; Risk assessment; Prognosis

waves in the ECG predict ischemic area, size and duration of ischemia [1] and the predictive value of ECG to determine mortality and other cardiac events (e.g. LV dysfunction, reinfarction) has been assessed in different studies [2,3]. In addition to ECG, biomarkers of myocardial necrosis like creatine kinase (CK) and its muscle brain isomer (CK-MB) have been shown to be reliable for predicting the prognosis of patients with myocardial infarction [4]. Our aim was to assess the role of the initial electrocardiogram and CK levels in patients with acute STEMI to predict subsequent myocardial dysfunction.

Patients and Methods

This cross-sectional study enrolled 124 patients who were discharged with the final diagnosis of STEMI from Loghman Hakim hospital between October 2003 and April 2006. The following criteria were met for the diagnosis of STEMI: 1) symptoms of cardiac ischemia (chest pain) lasting more than 30 minutes, 2) ST-segment elevation of \geq 1.0 mm in at least 2 contiguous leads and 3) subsequent typical rise and/or fall of CK levels (CKMB) [5]. Patients who showed confounding factors including history of congestive heart failure, left bundle branch block (either preexistent or new), ventricular pace rhythms, ventricular arrhythmias and those who lacked an initial ECG, three CK measurements or outcome data were excluded.

Patients' clinical and laboratory data were prospectively gathered and stored in a database for research purposes in the cardiology ward of Loghman Hakim hospital. Data from this database were analyzed for the study. In addition, 12-lead ECG recordings from patients were retrieved from hospital records and reviewed for the study. The initial ECG was the one that fulfilled the enrollment criteria and was used for analysis. A standard paper speed and amplification (25 mm per second, 10 mm/mV) was applied. ST deviation (elevation or depression) was measured 60 milliseconds (ms) after the J point relative to the preceding TP segment. The definitions of ECG variables were used according to other similar studies [2]. CK (activity) sum was defined as the sum of three CK

Introduction

The electrocardiogram (ECG) is one of the most accessible diagnostic tools to evaluate the acute coronary syndrome. Changes involving the ST segment, T waves and pathologic Q

measurements, while CK max was the greatest value of CK measured.

The main outcome measures of the study were left ventricular ejection fraction (LVEF) $\leq 40\%$ determined by echocardiography on days 3-5 after initial presentation. The patients with one of the following criteria had been recommended to carry out coronary angiography according to the guidelines of ACC/AHA [6]: 1) 1-14 days post MI angina; 2) sustained ventricular tachycardia (VT) or ventricular fibrillation (VF) after 48 hours of MI; 3) congestive heart failure (CHF) symptoms and signs or ejection fraction (EF) $\leq 40\%$; and 4) positive exercise tolerance test (ETT) or myocardial perfusion scan.

Quantitative variables are presented with mean \pm standard deviation. The qualitative variables are expressed with number and percent. The two groups of values were compared using the chi-square test. The independent samples t-test was used to compare the mean of quantitative variables in two groups. Univariate analysis was used to identify possible risk factors for the outcome measures. We used logistic regression analysis to identify independent and confounding variables. All variables with a statistical significance (p-value) of at least 0.2 in the univariate analysis were selected for the final model. A value of $p < 0.05$ was considered statistically significant. We used SPSS release 13.0 (SPSS Inc, Chicago, IL, USA) for all statistical tests.

Results

Table 1 Baseline characteristics of 124 patients with STEMI at Loghman Hakim hospital.

Characteristics	Number	Percent
Sex		
Male	91	73.4
Female	33	26.6
Risk factors		
Hypertension	33	26.6
Diabetes mellitus	23	18.5
Prior myocardial infarction	20	16.1
Renal failure	1	0.8
Current or recent smoking	43	34.7
Location of infarct (based on ECG)		
Anterior	52	41.9
Inferior	65	52.4
Anterior and inferior	6	4.8
Lateral	1	0.8

One hundred twenty-four eligible patients were reviewed. Their age ranged 33-84 years (mean 59.1 ± 12.6 years). Inferior MI was more frequent in patients < 50 -year-old in comparison

to patients ≥ 50 -year-old, but was not significant statistically (61% vs 50% , $p < 0.24$). Other baseline characteristics of the patients are shown in **Table 1**. The initial ECG showed sinus rhythm in 121 patients (97.6%) and atrial fibrillation in 3 (2.4%). Mean heart rate was 80.1 ± 22.9 beats per minute. Bradycardia was present in 16 patients (12.9%) and tachycardia in 18 (14.5%). Mean QRS duration was 72 ± 17 ms.

Echocardiography was performed in 117 patients (93.6%) during admission. The mean LVEF was 45.2 ± 11.3 . An LVEF $\leq 40\%$ was found in 52 patients (44.4%). Other complications after STEMI were: angina at rest in three patients (2.4%), cardiac arrest in two (1.6%) and pulmonary edema in another two patients.

The results of the univariate analysis to predict the outcome of LVEF $\leq 40\%$ are presented in **Tables 2A** and **2B**. Based on these results, diabetes mellitus, prior myocardial infarction, CK sum, CK max, the sum of absolute ST deviation, the sum of ST deviation in inferior leads (II, III and aVF), number of leads with ST elevation and maximum ST elevation were selected for the multivariate analysis. **Table 3** shows the results of the multivariate analysis.

Discussion

We found that the initial ECG and CK levels, which are readily available at any hospital, may provide important prognostic information and guide the subsequent treatment plan. The prognostic value of the initial ECG has been shown in several studies [2-4,7-10]. In one of the largest studies, Hathaway et al analyzed a clinical trial database of over 34000 patients and developed a nomogram to predict 30-day mortality in patients with STEMI who received thrombolytic therapy. Our study also addresses the utility of these simple diagnostic tests in terms of clinical decision making.

In several studies, even after primary PCI association of CK max with LV dysfunction and prognosis has been shown [11-14].

Risk factors for coronary artery disease in our patients and studies from western countries are compared in **Table 4**. The frequency of prior MI and diabetes mellitus were similar in our patients and other studies, but hypertension and smoking were found more frequently in patients from western countries. This difference warrants further investigation and may be the reason for the lack of association of these factors in our study. Coronary angiography was recommended to 68 patients (54.8%) at the time of discharge. (Indications of angiography were EF $\leq 40\%$ in 75% , positive ETT and positive perfusion scan in 12% , post MI angina in 11% and cardiac arrest in 2% of patients).

In two large studies with sample sizes of over 34000 and 12000 patients, several ECG variables were found to be related to clinical outcomes, including 30-day mortality [2,3]. However, results of studies based on data of patients enrolled in clinical trials should be interpreted with caution, because: 1) in the actual practice, it is not possible to administer thrombolytic therapy to all patients with STEMI due to contraindications or

late presentation of the patient and 2) trial populations have better outcomes than do general unselected populations.

Table 2A: Univariate associations for LVEF \leq 40% in 117 patients with STEMI. categorical variables (percent).

Variable	EF \leq 40%	EF > 40%
Sex		
Male	73.1	75.4
Female	26.9	24.6
Hypertension	26.9	26.2
Prior MI	23.1	7.7
Diabetes mellitus	25	13.8
Smoking	32.7	33.8
Thrombolytic therapy	44	50.8
Pathological Q waves	53.8	46.2

Table 2B: Continuous variables (mean \pm standard deviation).

Variable	EF \leq 40%	EF > 40%
Age (years)	59.9 \pm 13.3	58.5 \pm 12.5
CK sum (mg/dl)	4460.2 \pm 3484.5	2478.4 \pm 1660.7
CK max (mg/dl)	2518.3 \pm 1909.0	1381.6 \pm 975.9
ECG rate (beats per minute)	81.4 \pm 22.7	78.7 \pm 22.6
QRS duration (ms)	70.2 \pm 16.0	72.3 \pm 15.2
Sum of ST deviation in all leads (mm)	15.6 \pm 9.1	10.4 \pm 6.0
Sum of ST deviation in inferior leads (mm)	2.9 \pm 2.8	3.7 \pm 2.7
Sum of ST deviation in leads V1-V4 (mm)	7.9 \pm 5.7	3.6 \pm 3.9
Number of leads with ST elevation (mm)	5.9 \pm 1.8	\pm 1.7

Table 3: Multivariate odds ratios and 95% confidence intervals for predictors of left ventricular dysfunction (LVEF \leq 40%) in 117 patients with STEMI.

Variable	Odds ratio	95% CI
Prior MI	6.1	1.6-23.2
Diabetes mellitus	2.6	0.8-8.2
CK max (\times 1000 mg/dl)	2	1.3-2.9
Sum of ST deviation in all leads (mm)	1.1	1.1-1.2
Sum of ST deviation in inferior leads (mm)	0.7	0.6-0.9

Table 4: Comparison of the distribution of risk factors for coronary artery disease in our patients and studies from western countries.

Risk factor	Current study	Hathaway et al. [2]	Savonitto et al. [3]	Manes et al. [7]
Hypertension	27%	38%	41%	41%
Diabetes	18%	N/A	17%	21%
Prior MI	16%	16%	20%	16%
Smoking	35%	N/A	40%	N/A
N/A: not available.				

The frequency of the need for angiography in our patients (55%) was similar to the rate of coronary angiography performed during hospitalization (57%) in other studies [3].

The results of this study should be interpreted in the context of their limitations. Our results apply only to the initial ECG and serial ECGs were not analyzed in this study. Because the ST segment fluctuates throughout an infarction and rhythm disturbances may be transient, analysis of the "worst" ECG tracing would likely alter our results. The same concept applies to the LVEF. Studies have shown that recovery of LV function may be observed up to 90 days after MI. Therefore, an echocardiography performed a few days after MI may not show the long-term function of the left ventricle. The use of more sensitive and specific biochemical markers of myocyte injury (e.g. troponin) might improve the power of enzymatic risk stratification.

Conclusions

The initial ECG and CK levels in patients with STEMI may contain valuable information for risk stratification, determination of prognosis and the subsequent management plan.

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