Electrocardiographic characteristics of posterior myocardial infarction in comparison to angiographic findings

Hasan Shemirani[(1)], Elham Nayeri-Torshizi[(2)]

Original Article

Abstract

BACKGROUND: Myocardial infarction (MI) is a cardiac cell death following the imbalance of supply and demand. Electrocardiography (ECG) is a diagnostic test for MI and can help the clinicians to estimate the severity and size of infarction, to suggest the artery related to the infarct and localize the pathology. The aim of this study is to evaluate the diagnostic value of ECG in posterior MI (PMI) compared with angiographic findings.

METHODS: In a prospective observational study, using simple sampling patients with diagnosis of PMI (ST elevation in at least two consecutive leads V7, V8, and V9) were enrolled and all standard 12 leads and also V7, V8, V9 and right leads, including V3R and V4R were recorded and angiography was performed. ECG changes were recorded and compared with angiography findings.

RESULTS: In this study, totally 138 patients were enrolled (mean ± standard deviation age of 65.00 ± 12.97 and 76.8% male). Left circumflex artery (LCX), right coronary artery (RCA) and left anterior descending artery (LAD) occlusions occurred in 65.9, 50.7, and 29 percent respectively. Patients with LCX occlusion had a significantly higher frequency of ST elevation in V5, V6, I and AVL ($P \leq 0.001$). Patients with RCA occlusion had a significantly higher frequency of ST elevation in V1, V3R, and V4R and also ST depression in V5 and V6 ($P \leq 0.001$).

CONCLUSION: In PMI, there is a relationship between ECG findings and different coronary artery occlusions. Hence that ECG is a useful tool to predict the LCX or RCA occlusion in PMI.

Keywords: Angiography, Coronary Artery, Electrocardiography, Posterior Myocardial Infarction

Date of submission: 24 Apr 2014, ***Date of acceptance:*** 7 Jul 2014

Introduction

Cardiovascular diseases (CVD) are one of the most common causes of morbidity and mortality. Coronary artery disease (CAD) is a common form of CVD and is responsible for 22% of early and 15% of late deaths in patients with CVD.[1] Decrease in coronary artery flow has a wide range of symptom according to the severity of obstruction. It may be asymptomatic or symptomatic after exercise or at rest or may be more severe and causes myocardial infarction (MI).[2] MI is a cardiac cell death following the imbalance of supply and demand.[3] Posterior MI (PMI) is infarction of posterior wall resulting from occlusion of left circumflex artery (LCX) or right coronary artery (RCA) and is occurred in 15-20% of acute MIs.[4] It is hard to diagnose PMI and it is associated with a high 6 months mortality rate, especially if present with other myocardial wall ischemia.[5-7]

Different methods and criteria for diagnosis of MI such as considering the sign and symptoms, serological biomarkers, electrocardiography (ECG) and imaging are used.[8] ECG can help the clinicians to estimate the severity and size of infarction, to suggest the artery related to the infarct and localize the pathology.[9] It is mentioned that ECG is the most frequently used, a cost-benefit method and also most misinterpreted diagnostic test in cardiology.[10] It is clear that better tests and also development of the current methods in the diagnosis of MI are required. Hence, the aim of this study was to evaluate ECG characteristics of PMI compared to angiographic findings. This will prepare more information about the diagnostic characteristics of ECG in the diagnosis of PMI. There are some data and study about relationship between ECG and posterior wall MI and it is useful to find that because ECG is a diagnostic test 6-10.

1- Professor, Isfahan Cardiovascular Research Center, Isfahan Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
2- Resident, Cardiac Rehabilitation Research Center, Isfahan Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
Correspondence to: Elham Nayeri-Torshizi, Email: dr.nayeri1@yahoo.com

Materials and Methods

This was a prospective observational study conducted on a sample of 138 consecutive patients with evidence of acute coronary syndrome referred to Shahid Chamran and Noor Hospitals of Isfahan, Iran, in 2012. The inclusion criteria were as follow; (a) diagnosis of PMI according to ECG findings, (b) no streptokinase injection, (c) informed consent for performing angiography and (d) no contraindication for angiography. Patients with no net final diagnosis (not ruling out other diagnosis) and also with no regional wall motion abnormality (RWMA) of posterior wall (according to echocardiography) were excluded from the study. The study sample was selected using simple sampling.

Demographic characteristics including age and sex were recorded. Furthermore, past medical history, including hypertension (HTN), diabetes mellitus (DM), stroke, hyperlipidemia (HLP) and history of smoking were asked. All patients were undergone transthoracic echocardiography to determine the RWMA of posterior wall. Angiography was done using the standard technique, and the occluded arteries were defined. Before angiography ECG evaluation was performed for all participants. The ECGs were recorded at a speed of 25 mm/s and at a calibration of 1 mV = 10 mm using a Schiller Cardiovit recorder. All standard 12 leads and also V7, V8, V9 and right leads including V3R and V4R were recorded and were evaluated by two investigators blinded to angiography findings. PMI was assessed in all leads. PMI was defined as ≥ 1 mm ST elevation at least two consecutive leads of V7, V8 and V9. Also, other ECG changes including ST elevation in other leads, ST depression (> 1 mm), T change (T wave inversion > 3 mm) and pathological Q wave (Q-waves wider than 0.04 s or deeper than one-quarter of the R-wave) in all leads and R wave in V1 and V2 (R/S > 1 mm) were evaluated and recorded.[7,10,11]

Statistical analysis was performed using SPSS for Windows (version 16.0, SPSS Inc., Chicago, IL, USA). For categorical variables, chi-square test was used. Statistical significance was considered at the 0.05 probability level in all analyses, and the data are given as mean ± Standard deviation (SD) or number (%). Sensitivity, specificity, positive (PPV) and negative predictive value (NPV) were calculated according to the table 1.

The research protocol was approved by the Ethical committee of the Isfahan University of Medical Sciences in Iran, and an informed consent was obtained from all participants.

Table 1. Diagnostic power of the test electrocardiography (ECG)

ECG	Angiography (gold standard)		Total
	Positive	Negative	
Positive	TP	FP	TP + FP
Negative	FN	TN	FN + TN
Total	TP+FN	FP+TN	TP + FP + FN + TN

ECG: Electrocardiography; Sensitivity = TP/(TP + FN); Specificity = TN/(TN + FP); Positive predictive value = TP/(TP + FP); Negative predictive value = TN/(FN + TN); TP: True positive; FP: False positive; TN: True negative; FN: False negative

Results

In this study, 138 patients were enrolled. The mean age (± SD) of the participants was 65.00 ± 12.97 and 106 (76.8%) were male. Of the participants, 65 (47.1%), 55 (39.9%), 25 (18.1%), 58 (42%) and 55 (40.1%) had positive history of HTN, DM, stroke, HLP and smoking, respectively. Results of angiography showed that none of the participants had occlusion in left main coronary artery, 70 (50.7%) had RCA occlusion, 40 (29%) had left anterior descending artery (LAD) occlusion and 91 (65.9%) had LCX occlusion. Of the participants 35 (25.4%) had only RCA occlusion, 55 (39.9%) had only LCX occlusion, 13 (9.4%) had LCX and LAD occlusion, 8 (5.8%) had LCX and RCA occlusion, 12 (8.7%) had LAD and RCA occlusion and 15 (10.9%) had three-vessel (LCX, LAD and RCA) occlusion.

All patients had ST elevation in at least two consecutive leads of V7, V8 and V9 as it was the criteria to be included in this study. Tables 2 and 3 are reporting the frequencies of different ECG abnormalities and findings in all leads in patients with different types of coronary artery occlusions. According to table 2 and 3, patients with LCX occlusion had a significantly higher frequency of ST elevation in V5, V6, I and AVL (P ≤ 0.001). Also, they had a higher frequency of T changes in V3R and V4R (P = 0.011 and 0.004, respectively). Patients with RCA occlusion had a significantly higher frequency of ST elevation in V1, V3R and V4R (P ≤ 0.001). Also, they had a significantly higher frequency of ST depression in V5 and V6 (P ≤ 0.001) and T change in V6 (P = 0.046). Patients who had LAD occlusion in addition to LCX or RCA had a significantly higher frequency of ST elevation in V2, V3 and V4 (P ≤ 0.001) and ST depression in AVF (P = 0.028). In 81.9% and 84.1% of all patients ST elevation was recorded in leads II and III respectively. There was no significant difference between different artery

occlusions in ST elevation in leads II and III (P = 0.733 and 0.398, respectively) (Table 2). There were no significant differences between different types of coronary occlusions for R in V1 and V2 (P = 0.109 and 0.111 respectively).

According to the table 2 and 3, some criteria for diagnosis of the occluded coronary artery based on ECG findings are reported in table 4. As table 4 is reporting, if ST elevation in lead V5 or V6 be added to ST elevation in at least two consecutive leads of V7, V8 and V9, diagnostic power of ECG in LCX occlusion is as follow: sensitivity of 71.42% and specificity of 89.26%. If ST elevation in lead I or AVL be added to the mentioned criteria, specificity will increase to 97.87%, but sensitivity will decrease to 56.04%. For RCA occlusion, if ST elevation in lead V1 e added to ST elevation in leads of V7, V8 and V9, sensitivity and specificity of ECG in diagnosis of RCA occlusion will be 67.14% and 85.29%, respectively. If ST elevation in V3R or V4R is added to the mentioned criteria, sensitivity will be 60.00% and specificity will be 94.11%. Adding ST depression in V5 or V6 will decrease the sensitivity to 11.42%, but increase the specificity to 98.52%. Positive predictive value (PPVs) and negative predictive value (NPVs) are also reported in table 4.

Table 2. Frequency of different electrocardiographic findings of limb leads in patients with different coronary artery occlusions after posterior myocardial infarction

ECG change	ECG Leads					
	I	II	III	AVR	AVF	AVL
ST elevation						
Only RCA	3 (8.6)	28 (80.0)	31 (88.6)	1 (2.9)	33 (94.3)	3(8.6)
Only LCX	34 (61.8)	44 (80.0)	48 (87.3)	0 (0.0)	48 (87.3)	29 (52.7)
LCX + LAD	7 (53.8)	10 (76.9)	11 (84.6)	1 (7.7)	6 (46.2)	8 (61.5)
LCX + RCA	5 (62.5)	6 (75.0)	7 (87.5)	0 (0.0)	8 (100.0)	7 (87.5)
LAD + RCA	1 (8.3)	11 (91.7)	9 (75.0)	1 (8.3)	10 (83.3)	1 (8.3)
Three vessels	4 (26.7)	14 (93.3)	10 (66.7)	12 (80.0)	11 (73.3)	5 (33.3)
P	< 0.001	0.751	0.381	< 0.001	0.003	< 0.001
ST depression						
Only RCA	9 (25.7)	3 (8.6)	2 (5.7)	14 (40.0)	1 (2.9)	8 (22.9)
Only LCX	8 (14.5)	10 (18.2)	6 (10.9)	26 (47.3)	7 (12.7)	14 (25.5)
LCX + LAD	2 (15.4)	1 (7.7)	1 (7.7)	9 (69.2)	5 (38.5)	2 (15.4)
LCX + RCA	1 (12.5)	2 (25.0)	1 (12.5)	6 (75.0)	0 (0.0)	0 (0.0)
LAD + RCA	2 (16.7)	0 (0.0)	1 (8.3)	3 (25.0)	2 (16.7)	2 (16.7)
Three vessels	8 (53.3)	1 (6.7)	4 (26.7)	2 (13.3)	3 (20.0)	4 (26.7)
P	0.064	0.377	0.409	0.013	0.027	0.717
T change						
Only RCA	13 (37.1)	3 (8.6)	2 (5.7)	25 (71.4)	1 (2.9)	11 (31.4)
Only LCX	12 (21.8)	8 (14.5)	6 (10.9)	45 (81.8)	7 (12.7)	18 (32.7)
LCX + LAD	5 (38.5)	1 (7.7)	0 (0.0)	9 (69.2)	4 (30.8)	3 (23.1)
LCX + RCA	2 (25.0)	1 (12.5)	1 (12.5)	5 (62.5)	0 (0.0)	0 (0.0)
LAD + RCA	2 (16.7)	1 (8.3)	3 (25.0)	9 (75.0)	1 (8.3)	2 (16.7)
Three vessels	6 (40.0)	1 (6.7)	3 (20.0)	4 (26.7)	2 (13.3)	4 (26.7)
P	0.424	0.965	0.229	0.004	0.122	0.475
Pathological Q wave						
Only RCA	6 (17.1)	1 (2.9)	1 (2.9)	21 (60.0)	2 (5.7)	3 (8.6)
Only LCX	9 (16.4)	6 (10.9)	5 (9.1)	32 (58.2)	5 (9.1)	8 (14.5)
LCX + LAD	3 (23.1)	2 (15.4)	1 (7.7)	9 (69.2)	3 (23.1)	3 (23.1)
LCX + RCA	1 (12.5)	0 (0.0)	0 (0.0)	6 (75.0)	0 (0.0)	0 (0.0)
LAD + RCA	2 (16.7)	1 (8.3)	1 (8.3)	9 (75.0)	2 (16.7)	4 (33.3)
Three vessels	5 (33.3)	3 (20.0)	6 (40.0)	7 (46.7)	1 (6.7)	3 (26.7)
P	0.757	0.328	0.015	0.622	0.413	0.174

Data are given as frequency (percentage) of positive patients; ECG: Electrocardiography; LAD: Left anterior descending artery; LCX: Left circumflex artery; RCA: Right coronary artery

Table 3. Frequency of different electrocardiographic findings of precordial, posterior and right leads in patients with different coronary artery occlusions after posterior myocardial infarction

ECG change	ECG Lead										
	V1	V2	V3	V4	V5	V6	V7	V8	V9	V3R	V4R
ST elevation											
Only RCA	24 (68.6)	2 (5.7)	1 (2.9)	1 (2.9)	1 (2.9)	3 (8.6)	29 (82.9)	33 (94.3)	31 (88.6)	30 (85.7)	29 (82.9)
Only LCX	4 (7.3)	0 (0.0)	0 (0.0)	18 (32.7)	28 (50.9)	34 (61.8)	51 (92.7)	46 (83.6)	44 (80.0)	7 (12.7)	7 (12.7)
LCX + LAD	6 (46.2)	10 (76.9)	8 (53.8)	9 (69.2)	11 (84.6)	10 (76.9)	11 (84.6)	13 (100)	10 (76.9)	2 (15.4)	1 (7.7)
LCX + RCA	7 (87.5)	0 (0.0)	0 (0.0)	6 (75.0)	8 (100)	8 (100)	7 (87.5)	7 (87.5)	8 (100)	6 (75.0)	8 (100)
LAD + RCA	8 (66.7)	8 (66.7)	9 (75)	4 (33.3)	2 (16.7)	1 (8.3)	7 (58.3)	11 (91.7)	11 (91.7)	9 (75.0)	11 (91.7)
Three vessels	8 (53.3)	7 (46.7)	7 (53.8)	8 (53.3)	5 (33.3)	7 (46.7)	11 (73.3)	12 (80.0)	12 (80.0)	11 (73.3)	11 (73.3)
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.048	0.363	0.629	< 0.001	< 0.001
ST depression											
Only RCA	3 (8.6)	7 (20.0)	5(14.3)	7 (20.0)	7 (20.0)	6 (17.1)	3 (8.6)	2 (5.7)	3(8.6)	1 (2.9)	1 (2.9)
Only LCX	9 (16.4)	11 (20.0)	11 (20.0)	7(12.7)	6 (10.9)	4 (7.3)	2 (3.6)	10 (18.2)	8 (14.5)	8 (14.5)	8 (14.5)
LCX + LAD	3 (23.1)	1 (7.7)	2 (15.4)	2 (15.4)	1 (7.7)	2 (15.4)	1 (7.7)	0 (0.0)	3 (23.1)	1 (7.7)	1 (7.7)
LCX + RCA	0 (0.0)	4 (50.0)	3 (37.5)	1 (12.5)	0 (0.0)	0 (0.0)	1 (12.5)	1 (12.5)	0 (0.0)	2 (25.0)	0 (0.0)
LAD + RCA	1 (8.3)	2 (16.7)	2 (16.7)	3 (25.0)	4 (33.3)	5 (41.7)	4 (33.3)	1 (8.3)	0 (0.0)	2 (16.7)	0 (0.0)
Three vessels	4 (26.7)	5 (33.3)	3 (20.0)	4 (26.7)	6 (40.0)	6 (40.0)	2 (13.3)	3(20.0)	3 (20.0)	3 (20.0)	2 (13.3)
P	0.399	0.268	0.778	0.718	0.044	0.005	0.053	0.291	0.365	0.191	0.355
T change											
Only RCA	5 (14.3)	9 (25.7)	13 (37.1)	15 (42.9)	16 (45.7)	16 (45.7)	3 (8.6)	1 (2.9)	3 (8.6)	1 (2.9)	2 (5.7)
Only LCX	18 (32.7)	19 (34.5)	24 (43.6)	15 (27.3)	14 (25.5)	12 (21.8)	2 (3.6)	10 (18.2)	8 (14.5)	16 (29.1)	17 (30.9)
LCX + LAD	6 (46.2)	3 (23.1)	6 (46.2)	5 (38.5)	2 (15.4)	3 (23.1)	2 (15.4)	1 (7.7)	4 (30.8)	4 (30.8)	4 (30.8)
LCX + RCA	0 (0.0)	3 (37.5)	4 (50.0)	2 (25.0)	0 (0.0)	0 (0.0)	1 (12.5)	1 (12.5)	0 (0.0)	2 (25.0)	0 (0.0)
LAD + RCA	4 (33.3)	3 (25.0)	0 (0.0)	4 (33.3)	5 (41.7)	5(41.7)	4 (33.3)	1 (8.3)	0 (0.0)	2 (16.7)	0 (0.0)
Three vessels	4 (26.7)	3 (20.0)	3(20.0)	2 (13.3)	6 (40.0)	3 (20.0)	2(13.3)	2 (13.3)	1 (6.7)	0 (0.0)	1 (6.7)
P	0.086	0.851	0.030	0.380	0.058	0.054	0.045	0.312	0.214	0.004	0.003
Pathological Q wave											
Only RCA	2 (5.7)	4 (11.4)	7 (20.0)	6 (17.1)	6 (17.1)	8 (22.9)	2 (5.7)	1 (2.9)	0 (0.0)	0 (0.0)	0 (0.0)
Only LCX	7 (12.7)	8 (14.5)	9 (16.4)	6 (10.9)	4 (7.3)	3 (5.5)	2 (3.6)	6 (10.9)	6 (10.9)	12 (21.8)	12 (21.8)
LCX + LAD	4 (30.8)	2 (15.4)	4 (30.8)	4 (30.8)	2 (15.4)	2 (15.4)	0 (0.0)	0 (0.0)	2 (15.4)	1 (7.7)	1 (7.7)
LCX + RCA	1 (12.5)	1 (12.5)	2 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
LAD + RCA	2 (16.7)	2 (16.7)	2 (16.7)	3 (25.0)	2 (16.7)	3 (25.0)	4 (33.3)	1 (8.3)	1 (8.3)	1 (8.3)	0 (0.0)
Three vessels	5 (33.3)	4 (26.7)	3 (20.0)	3 (20.0)	6 (40.0)	5 (33.3)	1 (6.7)	1 (6.7)	2 (13.3)	3 (20.0)	2 (13.3)
P	0.085	0.829	0.861	0.315	0.046	0.022	0.035	0.644	0.157	0.017	0.015

Data are given as frequency (percentage) of positive patients; ECG: Electrocardiography; LAD: Left anterior descending artery, LCX: Left circumflex artery, RCA: Right coronary artery

Table 4. Evaluation the diagnostic power of electrocardiography in differentiation of coronary artery types occlusion on in patients with posterior myocardial infarction

Criteria	Angiography finding				Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
	Occluded		Not occluded					
	TP	FN	TN	FP				
LCX								
ST elevation in two consecutive leads of V7, V8, V9 (diagnosis of PMI by ECG)								
AND ST elevation in lead V5 or V6	65 (47.1)	26 (18.8)	42 (30.4)	5 (3.6)	71.42	89.36	92.85	61.76
AND ST elevation in lead I or AVL	51 (37.0)	40 (29.0)	46 (33.30)	1 (0.7)	56.04	97.87	98.07	53.48
RCA								
ST elevation in two consecutive leads of V7, V8, V9 (diagnosis of PMI by ECG)								
AND ST elevation in lead V1	47 (34.1)	23 (16.7)	58 (42.0)	10 (7.2)	67.14	85.29	82.45	71.60
AND ST elevation in lead V3R or V4R	42 (30.4)	28 (20.3)	64 (46.4)	4 (2.9)	60.00	94.11	91.30	69.56
AND ST depression in V5 or V6	8 (5.8)	62 (44.9)	67 (48.6)	1 (0.7)	11.42	98.52	88.88	51.93

TP: True positive; FN: False negative; TN: True negative; FP: False positive; PPV: Positive predictive value; NPV: Negative predictive value; LCX: Left circumflex artery; RCA: Right coronary artery; ECG: Electrocardiography; PMI: Posterior myocardial infarction; AND means plus all above

Discussion

Standard leads of ECG are insensitive tool in identifying the PMI because they don't directly view the posterior wall.[7] As there are limited studies conducted on ECG properties of patients with PMI, the aim of the current study was to evaluate ECG characteristics of PMI in comparison to angiographic findings.

Our results showed that in patients with PMI, LCX occlusion was the most frequent occlusion (LCX > RCA > LAD). No left main coronary artery occlusion was defined. Previous reports have shown that PMI is usually caused by occlusion of LCX.[11,12] In addition, our results revealed that patients with LCX occlusion had a significantly higher frequency of ST elevation in V5, V6, I and AVL and T changes in V3R and V4R. According to previous studies, LCX supplies a small ventricular area, and ST elevation will occur in less than half cases. However when ST elevation happens, it is more often seen in leads II, III and AVF and also V5, V6 and AVL in patients with PMI. Also, it is reported that ST elevation in leads V5 and V6 are associated with LCX occlusion.[13,14] Kim et al. showed that patients with PMI diagnosed as having LCX occlusion have significantly higher frequency of ST elevation in leads I, AVL, V5 and V6 than patients with LAD and RCA occlusions.[15] Study conducted by Bairey et al. showed that patients with LCX occlusion had ST elevation in one or more lateral leads including AVL, V5 or V6 and it was significantly different from patients with RCA occlusion.[16] Also another study has reported the same results and revealed that patients with LCX lesion have most often ST elevation in V6.[17] In the current study, patients with RCA occlusion had a significantly higher frequency of ST elevation in V1, V3R and V4R and ST depression in V5 and V6 and T change in V6. Study of Birnbaum et al. showed that ST depression in leads V4 to V6 associated with higher probability of RCA occlusion.[18] By considering ST elevation in leads V5 or V6, LCX occlusion will be diagnosed with sensitivity of 71.42% and specificity of 89.26%. If ST elevation in leads I or AVL is added to the mentioned, sensitivity and specificity will be 56.04% and 97.87% respectively. According to our results, if ST elevation in lead V1 is considered, sensitivity and specificity of ECG in the diagnosis of RCA occlusion in patients with PMI will be 67.14 and 85.29% respectively. If ST elevation in V3R or V4R is added to the mentioned criteria, sensitivity will be 60.00%, and specificity will be 94.11%.

Conclusion

According to our results in PMI, there is a relationship between ECG findings and different coronary artery occlusions. So that ECG is a useful tool to predict the LCX or RCA occlusion in PMI. Also our results are suggestive of paying more attention and record posterior leads (V7, V8 and V9) when ECG changes such as ST elevation in lead V5 or V6 in addition to ST elevation in leads I or AVL or ST elevation in lead V1 in addition to ST elevation in lead V3R or V4R occurs during acute coronary syndromes.

Acknowledgments

The authors appreciate the mentioned deputy and the staffs of Chamran and Noor Hospitals for their kind cooperation.

Conflict of Interests

Authors have no conflict of interests.

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How to cite this article: Shemirani H, Nayeri-Torshizi E. **Electrocardiographic characteristics of posterior myocardial infarction in comparison to angiographic findings.** ARYA Atheroscler 2015; 11(1): 30-5.