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Electrocardiographic predictors of proximal left anterior descending coronary artery occlusion

Research Article

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Abstract: Proximal occlusion of the left anterior descending coronary artery (LAD) results in a less favorable prognosis in coronary angiography. Therefore, it is important to determine whether there are significant lesions in LAD by electrocardiography (ECG) before coronary angiography. Twelve-lead ECG was compared in 130 patients with significant lesions (≥70% stenosis) confined to proximal part of the LAD (P LAD group) and 492 patients with normal coronary angiography (control group). Fifty-nine patients in the P LAD group and 18 patients in the control group had signs of anterior myocardial infarction as shown by ST elevation (≥1.0 mV) in two consecutive pericardial leads or the presence of a pathological Q wave. An inverted U wave (biphasic T wave) in leads V_1 to V_4 had a sensitivity of 49.3% (35/71) in P LAD patients without signs of anterior myocardial infarction (MI) and 96.6 % (57/59; specificity, 66.6%; positive predictive value, 90.9 %) in the P LAD patients with signs of anterior MI. In the P LAD patients with signs of anterior MI, T inversion in V_4-V_5 had a lower sensitivity (67.0% [40/59]) than an inverted U wave. ST depression in inferior leads and ST depression in V5 were not useful markers of proximal LAD occlusion. In conclusions, an inverted U wave in V_1 to V_4 (or in each of these leads) and T inversion in V_4-V_5 are the best predictors of significant proximal LAD lesion, especially in patients with ECG findings of anterior MI.

Keywords: *Left anterior coronary artery • Coronary angiography • Electrocardiogram*

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1. Introduction

The proximal left anterior descending coronary (LAD) artery has a tendency to develop atherosclerotic occlusive disease [1]. Moreover, due to the large territory of LAD arterial blood supply, occlusion of the proximal part of this artery is associated with a less favorable outcome and prognosis [2-4]. Most studies have shown a poor correlation between the electrocardiogram (ECG) results and the exact extent of myocardial involvement as determined by autopsy [5,6]. In previous studies, proximal LAD artery lesion before branching S_1 (first septal branch) and/or D_1 (first diagonal branch) could be predicted by the 11 ECG parameters [7-18], namely, ST-segment depression (≥1.0 mm) in inferior leads, ST-segment elevation (≥1.0 mm) in lead aVL, ST-segment depression (≥1.0 mm) in lead aVL, ST-segment elevation (≥0.5 mm) in lead aVR, ST-segment elevation (≥2.5 mm) in lead V_1, ST-segment elevation (<2.5 mm) in lead V_1, ST-segment elevation (≥1.0 mm) in lead V_2, inverted U wave in lead V_1 to lead V_4, ST-segment depression (≥1.0 mm) in lead V_5, T inversion in lead V_4 and/or lead, and a Q wave in lead V_4 to lead V_6. We decided to asses these ECG findings to predict whether significant lesions in the proximal LAD artery were present in patients with and without signs of anterior myocardial infarction (MI).

2. Material and Methods

2.1. Patients

Between June 2005 and June 2006, we studied 1517 angiography cases from our hospitals of Shiraz University of Medical Sciences . One hundred and forty-two patients had significant lesions (>70% stenosis) [19] confined to the proximal part of LAD artery, before branching S_1 and/or D_1, and without significant lesions in other coronary arteries. These patients had chronic stable angina. We excluded

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Table 1. Demographic features of different groups.

	Total Cases	Male		Female		Age ± Standard
		Number	Percent	Number	Percent	Deviation(year)
Normal	492	207	42.1 %	285	57.9 %	54 ± 11
Normal+MI	18	8	44.4 %	10	55.6 %	54 ± 5
Normal-MI	474	199	42.0 %	275	58.0 %	54 ± 11
P LAD	130	90	69.2 %	40	30.8 %	55 ± 12
P LAD+MI	59	47	79.7 %	12	20.3 %	54 ± 13
P LAD-MI	71	43	60.6 %	28	39.4 %	56 ± 10

MI: Myocardial Infarction / P LAD: Proximal Left Anterior Descending Coronary Artery.

Table 2. Number of each ECG parameters in different groups.

Groups	Normal	Normal + MI	Normal – MI	P LAD	P LAD + MI	P LAD – MI
ECG parameters	(n=492)	(n=18)	(n=474)	(n=130)	(n=59)	(n=71)
ST↓ in inferior leads	25	1	24	10	6	4
ST↑ in lead aVL	8	1	7	12	11	1
ST↓ in lead aVL	35	2	33	21	13	8
ST↑ in lead aVR	100	3	97	34	20	14
ST↑ (≥2.5mm) in lead V1	0	0	0	1	1	0
ST↑ (<2.5mm) in lead V1	21	2	19	11	10	1
ST↑ in lead V2	28	5	23	31	25	6
Inverted U wave in lead V1 to V4	41	6	35	92	57	35
ST↓ in lead V5	86	3	83	22	9	13
T inversion in lead V4 - V5	100	7	93	62	40	22
Q wave in lead V4 to V6	2	2	0	12	12	0

ST↓: ST segment depression / ST↑: ST segment elevation / MI: Myocardial Infarction / P LAD: Proximal Left Anterior Descending Coronary Artery

12 patients with complete left bundle branch block, left ventricular hypertrophy, heart rate ≥ 100/min, previous cardiac surgery, previous angioplasty, or valvular disease. The remaining 130 patients (P LAD group) were separated into two groups according to ECG signs of anterior MI. The P LAD + MI group was defined as patients in the P LAD group with signs of anterior MI in ECG as indicated by ST elevation (≥1.0 mV) in two consecutive precordial leads or pathological Q wave. Patients in the P LAD – MI group lacked signs of anterior MI in their ECG. The normal group included 492 patients with normal angiography or nonsignificant lesions. Of these, 18 had signs of anterior MI (normal + MI group). Table 1 shows the demographic data for these groups.

2.2. Coronary Angiography

Angiographic films were available for 1517 patients. One observer who was blinded to previous angiographic reports and ECG findings, reviewed the films and confirmed the 130 patients in P LAD group and the 492 patients in the normal group. The patients in the P LAD group had significant lesions (reduction in lumen size ≥ 70%) only in proximal part of LAD artery and before branching D_1 and/or S_1. The normal group was defined as patients without significant lesions in any of the coronary arteries.

2.3. ECG

Standard 12-lead ECG (recording velocity, 25 mm/second; calibration, 1 mV = 10 mm) was taken 12 h before performing angiography. In patients presenting with anterior MI, ECG was taken at the time of admission. The TP segment was defined as the isoelectric segment. The PR-segment was defined as the point when the T- and P-waves merged. ST-segment depression (ST ↓) and ST-segment elevation (ST ↑) was measured at the J-point. One observer who was blinded to angiographic reports and films studied the electrocardiograms and determined the ECG findings, described above.

Table 3. Sensitivity, specificity and positive predictive value of each ECG parameters in different groups.

ECG parameters / Groups	SENSITIVITY (%)			SPECIFICITY (%)			POSITIVE PREDICTIVE VALUE (%)		
	P LAD	P LAD + MI	P LAD – MI	P LAD	P LAD + MI	P LAD – MI	P LAD	P LAD + MI	P LAD – MI
ST↓ in inferior leads	7.7	10.2	5.6	94.9	94.4	94.9	28.5	85.7	14.2
ST↑ in lead aVL	9.2	18.6	1.4	98.3	94.4	98.5	61.9	92.3	12.5
ST↓ in lead aVL	16.2	22.0	11.3	92.8	88.8	93.0	39.6	86.6	23.2
ST↑ in lead aVR	26.2	33.9	19.7	79.6	83.3	79.5	27.0	88.0	13.3
ST↑ (≥2.5mm) in lead V1	0.8	1.7	0.0	100.0	100.0	-	100.0	100.0	-
ST↑ (<2.5mm) in lead V1	8.5	16.9	1.4	95.7	88.8	95.9	40.0	85.7	9.5
ST↑ in lead V2	23.8	42.4	8.5	94.3	72.2	95.1	55.5	84.3	25.8
Inverted U wave in lead V1 to V4	70.8	96.6	49.3	91.6	66.6	92.6	70.5	90.9	52.0
ST↓ in lead V5	16.9	15.3	18.3	82.5	83.3	82.4	21.8	76.9	14.4
T inversion in lead V4 - V5	47.7	67.0	31.0	79.6	61.1	80.3	39.7	85.7	20.5
Q wave in lead V4 to V6	9.8	20.3	0.0	99.5	88.8	100.0	85.7	87.7	-

ST↓: ST segment depression / ST↑: ST segment elevation / MI: Myocardial Infarction / P LAD: Proximal Left Anterior Descending Coronary Artery

2.4. Statistical Analysis

The data analyzed using SPSS version 13.0 for Windows (SPSS Inc. Chicago, IL). Sensitivity, specificity, and positive predictive values for each ECG finding in the P LAD, P LAD + MI, and P LAD – MI groups were determined. Control groups were the normal, normal + MI, and Normal – MI groups. Next, each parameter was compared between the P LAD group and its control group was made using a chi-square test or Fisher's exact test. A P-value below 0.05 was considered as indicating a statistically significant difference.

3. Results

Demographic features of the different groups are described in Table 1. The various ECG parameters were compared between the different groups (Tables 2-4).

Factors that did not predict proximal LAD lesions included the following: ST ↓ (≥1.0 mm) in inferior leads, ST ↑ (≥1.0 mm) in lead aVL, ST ↓ (≥1.0 mm) in lead aVL, ST ↑ (≥0.5 mm) in AVR, ST ↑ (≥2.5 mm) in lead V_1, ST ↑ (<2.5 mm) in lead V_1, ST ↑ (≥1.0 mm) in lead V_2, ST ↓ (≥1.0 mm) in lead V_5, Q wave in lead V_4 to lead V_6. The frequency of ST ↑ (≥1.0 mm) in lead V_2 was approximately five times higher in P LAD + MI (42.4%) than in the P LAD − MI group (8.5%), but the chi-square test showed that this parameter could not be used to predict proximal LAD artery lesions (P = 0.266).

Factors that predicted a proximal LAD lesion included the following: an inverted U wave (biphasic T wave) in lead V_1 to lead V_4; and an inverted U wave or biphasic T wave in leads V_1 to V_4, which was the most sensitive predictor at 96.6% (57/59) of the 11 ECG parameters. This ECG patternhad a specificity of 66.6 % and can be used to screen for proximal LAD artery lesion in patients with signs of anterior MI in ECG (positive predictive value of 90.9%). An inverted U wave (biphasic T wave) was seen in 35 patients (49.3%) in the P LAD − MI group, 6 of the patients in the normal + MI group (33.3%), and 35 patients in the normal − MI group (7.4%). The P value was below 0.0001, indicating that this ECG finding can predict a proximal LAD artery lesion even in patients without signs of anterior MI, but due to its low sensitivity (positive predictive value of 52.0%), it is not a good parameter for screening parameter. Figure 1 shows a comparison of the sensitivity and positive predictive value of this ECG pattern in the different groups.

T inversion in lead V_4 and/or lead V_5 was predictive of proximal LAD artery lesion not only in patients with signs of anterior MI (P = 0.028) but also in patients without signs of anterior MI (P = 0.029). This ECG pattern had a sensitivity of 67.0% in the P LAD + MI group and 31.0% in the P LAD – MI group. After an inverted U wave (Biphasic T wave) in lead V_1 to lead V_4, this was the most sensitive parameter for predicting lesions in the proximal LAD artery.

We next evaluated the significance of different factors for predicting proximal LAD lesion in all patients with and without MI using multivariable analysis. As a continuous variable, unadjusted for any other factors, an inverted U wave (biphasic T wave) in lead V_1 to lead V_4 was a significant predictor of a proximal LAD lesion. We also examined interaction between other ECG parameters and proximal LAD lesions (Table 5).

Table 4. P-values of each ECG parameter in P LAD+ MI group & P LAD – MI group.

	P LAD + MI group	P LAD – MI group
ST↓ in inferior leads	.109	.839
ST↑ in lead aVL	.180	.964
ST↓ in lead aVL	.306	.200
ST↑ in lead aVR	.162	.884
ST↑ (≥2.5mm) in lead V1	1.000	
ST↑ (<2.5mm) in lead V1	.550	.277
ST↑ in lead V2	.266	.208
Inverted U wave in lead V1 to V4	<.0001	<.0001
ST↓ in lead V5	.885	.869
T inversion in lead V4 - V5	.028	.029
Q wave in lead V4 to V6	.374	

ST↓: ST segment depression / ST↑: ST segment elevation / MI: Myocardial Infarction / P LAD: Proximal Left Anterior Descending Coronary Artery

Table 5. Partial correlation coefficients relating different ECG parameters to proximal LAD lesion.

Measurement	Partial Correlation	P-value
ST↓ in inferior leads	0.009	NS
ST↑ in lead aVL	0.008	NS
ST↓ in lead aVL	0.011	NS
ST↑ in lead aVR	0.098	<0.05
ST↑ (≥2.5mm) in lead V1	0.009	NS
ST↑ (<2.5mm) in lead V1	0.010	NS
ST↑ in lead V2	0.061	<0.05
Inverted U wave in lead V1 to V4	0.198	<0.05
ST↓ in lead V5	0.011	NS
T inversion in lead V4 - V5	0.191	<0.05
Q wave in lead V4 to V6	0.184	<0.05

NS, not signficant

Finally, all ECG parameters (covariates) were included in a multivariate model. This analysis showed that an inverted U wave (biphasic T wave) in lead V_1 to lead V_4 is the strongest predictor of a proximal LAD lesion, even after adjusting for established covariates. ST-segment elevation (≥1.0 mm) in lead V_2, T inversion in lead V_4 and/or V_5, and a Q wave in lead V_4 to V_6 significantly correlated with proximal LAD lesions in multivariate analysis, but the correlation was weaker than for an inverted U/biphasic T wave (Table 5).

4. Discussion

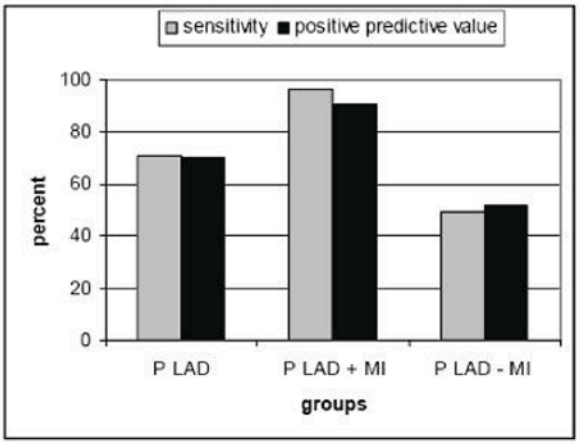
This article describes several new findings regarding the use of ECG findings to predict significant proximal LAD artery lesions. Previous studies showed that ST ↓ in inferior leads is a useful marker for identifying proximal LAD artery occlusion during MI [8,13,16,17]. This parameter has also been correlated with the severity of anterior wall ischemia [20-21]. ST↓ in inferior leads is believed to be a reciprocal change of ↑ ST in lead aVL 8 and associated with transmural ischemia in the high antero-basal region [22,23].In our study, although the frequency of ST ↓ in inferior leads was twice as high in the P LAD + MI group than in the normal + MI group, the difference was not statistically significant. In previous studies, ST ↑ in lead aVL has been shown to correspond with a high prevalence of lesions proximal to D_1 and S_1 [8,24,25]. This lead can capture the potentials of the antero-lateral wall of the left ventricle, which is irrigated by the LAD artery, so that a proximal lesion of the LAD artery would cause transmural ischemia with ST ↑ in lead aVL [8]. However, we found here that ST ↑ or ST ↓ in lead aVL had sensitivities of 18.6% and 22.0%, respectively, so they are unable to predict lesions in the P LAD + MI group.

ST elevation in lead aVR is found only in unstable angina where three vessels have coronary lesions and in patients with left main coronary artery lesion [26,27]. Engelen et al. described the relationship between aVR and LAD lesion proximal to its S_1 branch [7]. In this study, we did not find a correlation between ST ↑ in lead aVR and the presence of a proximal LAD lesion. According to our findings, ST ↑ in leads V_1 and V_2 is not useful for locating lesions in the proximal part of the LAD. This is in contrast to the report by Engelen et al., who suggested that ST elevation in lead V_1 (≥2.5 mm) is the only ECG parameter that can be used to discriminate between proximal and distal LAD occlusion in individual patients [7].

ST elevation in lead V_5 is a reciprocal change to transmural ischemia high in the antero-septal area of the heart. This finding appeared to be very specific for LAD occlusion proximal to S1 [7]. Contrary to Engelen's report, there was no significant difference between the normal +MI group and P LAD + MI group in this parameter. This parameter is therefore not useful for determining the presence of proximal LAD artery lesion in patients with stable angina.

A pathological Q wave in leads V_4 through V_4, associated in some studies [7], were indicative of occlusion distal to S_1. Our study did not show a relationship between a Q wave in these leads and proximal LAD artery lesions. This may be due to collateral circulation. De Zewaan et al. presented a typical ECG finding indicating proximal LAD lesion in an unstable angina patient and concluded that concave ST elevation up to 1 mm passing to a negative T wave in V_2 and V_3 might be a factor for

Figure 1. Sensitivity & positive predictive value of inverted U wave in differnet groups.



MI: Myocardial Infarction / P LAD: Proximal Left Anterior Descending Coronary Artery.

poor prognosis in acute coronary syndrome [28].

In this study, we evaluated stable angina patients, and we concluded that an inverted U wave (biphasic T wave) in lead V_1 through V_4 (or each of these) is the most sensitive parameter for predicting lesions in the P LAD + MI group, but the specificity was low (66.6 %). Because of the very high sensitivity and positive predictive value, it can be used to screen for proximal LAD artery occlusion in patients without signs of anterior MI, although with low sensitivity and a low positive predictive value. After a finding of an inverted U wave, T inversion in lead V_4 and/or lead V_5 can differentiate proximal LAD lesions from other coronary arteries. Although its sensitivity is low (31.0 %) in the P LAD − MI group, it can predict proximal LAD lesions in patients without signs of anterior MI (specificity, 80.3%; positive predictive value, 20.5%).

There are some limitations of the presented research. In the current study, we recognized anterior MI only by ECG findings. Therefore, patients with old MI were not excluded, and not all cases were in the acute phase of anterior MI. This may be the cause of the different results in our study and the previous studies. Also, we studied ECG findings in patients with single-vessel disease and lesions confined to proximal part of LAD, and two- and three-vessel disease involving the proximal LAD were excluded.

In conclusions our study shows that ECG is a useful tool in determining the presence of proximal LAD lesion, especially in patients with signs of anterior MI. An inverted U wave (biphasic T wave) in lead V_1 through V_4 (or each of these) can be used to identify proximal LAD lesions in patients with signs of anterior MI. It is also useful in patients with stable angina pectoris, although the sensitivity is low. Multivariate analysis showed that an inverted U (biphasic T wave) in leads V_1 to V_4 is the strongest predictor of a significant proximal LAD lesion in stable angina patients. T inversion in lead V_4 and/or lead V_4 can predict a proximal LAD lesion, especially in anterior MI.

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