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Original Article

Diagnostic performance of electrocardiography in the assessment of significant coronary artery disease and its anatomical size in comparison with coronary angiography

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Abstract

BACKGROUND: Current study addressed the predictive value of 12-lead electrocardiogram (ECG) in patients with suspected coronary artery disease (CAD).

METHODS: Four hundred consecutive patients with new onset of chest pain were studied. A resting standard 12-lead ECG was recorded and all patients underwent coronary angiography.

RESULTS: ECG correctly detected significant stenosis in 176 out of 400 patients with an overall sensitivity per patient of 51.5% and specificity per patient of 66.1%. Based on artery analysis, ECG had the highest and lowest sensitivity for the detection of involvement in LAD (37.3%) and RCA (25.8%), respectively. ROC curve analysis showed that ECG changes were not good indicators of coronary arteries involvement with areas under the ROC curves 0.586 (for LAD artery), 0.524 (for RCA artery) and 0.530 (for LCX artery).

CONCLUSIONS: ECG has low partial sensitivity and specificity for predicting coronary artery stenosis with accuracy ranged 58.5 to 62.0 percent based on coronary artery analysis.

KEYWORDS: Electrocardiogram, Angiography, Coronary Artery Disease, Sensitivity, Specificity.

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Early diagnosis of coronary atherosclerosis is mainly based on some risk stratification approaches, including medical history, physical examination, an electrocardiogram and serum cardiac marker measurements and therefore the diagnosis requires a careful review of cardiac ischemia manifestations. Because of the life-threatening character of coronary artery disease (CAD), its diagnosis necessitates rapid decision-making.[1] Catheter-based invasive coronary angiography is a useful strategy in patients with suspected CAD especially with high prevalent baseline cardiac risk factors. This applied tool is the gold standard of reference technique for direct assessment of the severity of coronary stenosis. However, it can be associated with certain risks, need to hospitalization as well as its related in-hospital complications.

The use of noninvasive assessment tools for predicting CAD has been recently considered mainly because it offers safety, patient convenience, and faster performance.[2, 3] Some studies have been focused on more simple, accurate and cost-benefit tools such as the standard 12-lead electrocardiogram (ECG) for diagnosis of CAD. The recognition and management of patients with CAD has relied to a large extent on the ECG for assessing ST-segment changes, T inversion and Q wave appearance associated

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with ischemia. Recently, it was shown that the ECG is reasonably specific but less sensitive predictors of cardiac ischemia in both human and animal models.[4] Fesmire and Percy noted that the initial 12-lead ECG had sensitivity of only 55% in patients ultimately diagnosed with acute coronary syndrome.[5] Similarly, Rude et al. showed that less than 50% of those diagnosed with acute myocardial infarction demonstrated ST-segment changes on their initial ECG.[6]

Although the accuracy of this tool for significant ischemia can be determined based on pooled data of the studies, heterogeneity of methods and patient selection may reduce the accuracy of results of the pooled data. The current study addressed the diagnostic value of the ECG for the detection of significant CAD, in comparison with conventional invasive coronary angiography.

Methods

Overall, 400 consecutive patients (mean age 54.52 ± 10.29 years, ranged 24 – 86 years, 56.5% male) with new onset of chest pain that were referred to Shafa hospital in Kerman, Iran and hospitalized in the CCU ward between January and December 2008 were included in this study. We excluded patients with other severe concomitant diseases. The study was carried out according to the principles of Helsinki declaration. The protocol was approved by the institutional review board of Kerman University of Medical Sciences and informed consents were obtained from all participants.

At admission, a resting standard 12-lead ECG was recorded and the ECG changes were interpreted by an attending cardiologist. The ECG was recorded as normal or abnormal depending on regional changes in ST segment (ischemic-appearing ST depression or elevation), T-wave inversion (≥ 1 mm) and Q-wave appearance (≥ 0.04 s or ≥ 25% of R-wave amplitude). The III, aVF and II leads were used to detect RCA involvement; V2 or V3 and aVL to detect LCX involvement, and V2 or V3, V1, and V4 were used to detect LAD involvement.[7] ECGs were taken at a paper speed of 25 mm/s and calibration of 10 mm/mV (Multipurpose ECG, FCP-4830, Fukuda Denshi, Tokyo, Japan) and interpreted at a core reading laboratory by a single investigator.

All enrolled participants also underwent coronary angiography by a staff blinded to the subject data. Patients with at least one stenosis, ≥ 50% diameter, were classified as having significant CAD.

Quantitative data are presented as means ± standard deviations or percentages. Coronary angiography was considered the gold standard. Descriptive statistics including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ECG in determining significant coronary artery stenosis were calculated. Predictive values of ECG between the two genders were compared using chi-square test. Receiver operator characteristic (ROC) curves were constructed to investigate the diagnostic efficacy. Statistical analyses for these parameters were performed by an independent statistician, using SPSS version 16.0 for windows (SPSS Inc., Chicago, IL, USA).

Results

According to the coronary angiography reports, 229 out of 400 participants had significant coronary artery stenosis. Therefore, the prevalence of significant CAD was 57.3%. ECG correctly detected significant stenosis in 176 patients with an overall sensitivity per patient of 51.5%. Angiography did not find significant stenosis in 171 cases that 66.1% of them were correctly diagnosed as negative by ECG, yielding a specificity of 66.1%. Accuracy of the presence or absence of significant coronary disease using ECG was 57.8%.

Based on artery analysis, ECG had the highest and lowest sensitivity for the detection of LAD (37.3%) and RCA (25.8%) involvement, respectively (Table 1). In addition, ECG had the highest accuracy for the detection of RCA involvement (62.0%), and the lowest accuracy for the detection of LAD involvement (58.5%). Sensitivity, specificity and predictive values of ECG were not statistically different between

Table 1. Predictive power of electrocardiogram for diagnosis of coronary artery involvement in comparison with coronary angiography

Artery	Sensitivity	Specificity	PPV	NPV	Accuracy
LAD	37.3%	79.9%	65.2%	55.8%	58.5%
RCA	25.8%	79.0%	36.7%	69.4%	62.0%
LCX	27.8%	78.3%	38.9%	68.5%	61.5%

PPV: Positive Predictive Value
NPV: Negative Predictive Value

the two genders (Table 2).

Regarding predictive power of ECG parameters for detection of coronary artery involvement, T-wave inversion had the highest sensitivity and ST-segment elevation had the lowest sensitivity for detection of LAD involvement (Table 3). Q wave had the highest sensitivity for detection of involvement in both RCA and LCX arteries. Accuracy of ST-segment elevation and ST-segment depression for detection of coronary arteries stenosis ranged between 50.0 – 68.0% and 50.0 – 65.5%, respectively. Also, accuracy of T-wave inversion ranged between 57.5 – 68.3% and accuracy of Q-wave appearance ranged between 55.3 – 65.8% for detection of coronary involvements (Figure 1).

According to the ROC curve analysis, ECG changes were not good indicators of coronary arteries involvement with areas under the ROC curves of 0.586 (for LAD artery), 0.524 (for RCA artery) and 0.530 (for LCX artery) (Table 4 & Figure 2).

Discussion

Initial ECG has been known as an important routine part of the assessment in more than two-third of patients with angina.[8] Pervious studies focused not only on cost-beneficial aspect and feasibility of this tool, but on its prognostic and predictive values.[9] Among the patients with chest pain, the prompt and accurate detection of acute coronary syndrome remains an important clinical challenge for specialists.

Table 2. Predictive power of electrocardiogram for diagnosis of coronary artery involvement in comparison with coronary angiography in men and women

Artery	Sensitivity	Specificity	PPV	NPV	Accuracy
LAD					
Men	37.1	84.3	74.2	52.4	58.4
Women	37.7	75.3	54.7	60.3	58.6
P-value	0.932	0.115	0.004	0.273	0.978
RCA					
Men	30.0	75.3	40.0	66.3	59.3
Women	18.8	83.3	30.0	72.9	65.5
P-value	0.161	0.288	0.255	0.435	0.485
LCX					
Men	30.6	75.2	42.6	64.2	58.4
Women	22.9	81.7	32.4	73.6	65.5
P-value	0.341	0.388	0.247	0.266	0.420

PPV: Positive Predictive Value
NPV: Negative Predictive Value

Table3 . Predictive power of electrocardiogram criteria for diagnosis of coronary artery involvement in comparison with coronary angiography

Criteria	Sensitivity	Specificity	PPV	NPV
LAD artery:				
ST-depression	4.0 %	96.5 %	53.3 %	49.9 %
ST- elevation	0.5 %	100 %	100%	49.9 %
T-inversion	29.9 %	85.4 %	67.4 %	54.7 %
Q wave	16.4 %	94.5 %	75.0 %	52.8 %
RCA artery:				
ST-depression	0.0 %	96.3 %	0.0 %	67.2 %
ST- elevation	0.7 %	99.6 %	50.0 %	68.1 %
T-inversion	17.2 %	92.3 %	51.2 %	70.3 %
Q wave	18.8 %	87.9 %	42.1 %	69.7 %
LCX artery:				
ST-depression	2.3 %	96.6 %	25.0 %	66.5 %
ST- elevation	0.8 %	99.6 %	50.0 %	66.8 %
T-inversion	13.5 %	89.5 %	39.1 %	67.5 %
Q wave	18.0 %	87.6 %	42.1 %	68.2 %

PPV: Positive Predictive Value
NPV: Negative Predictive Value

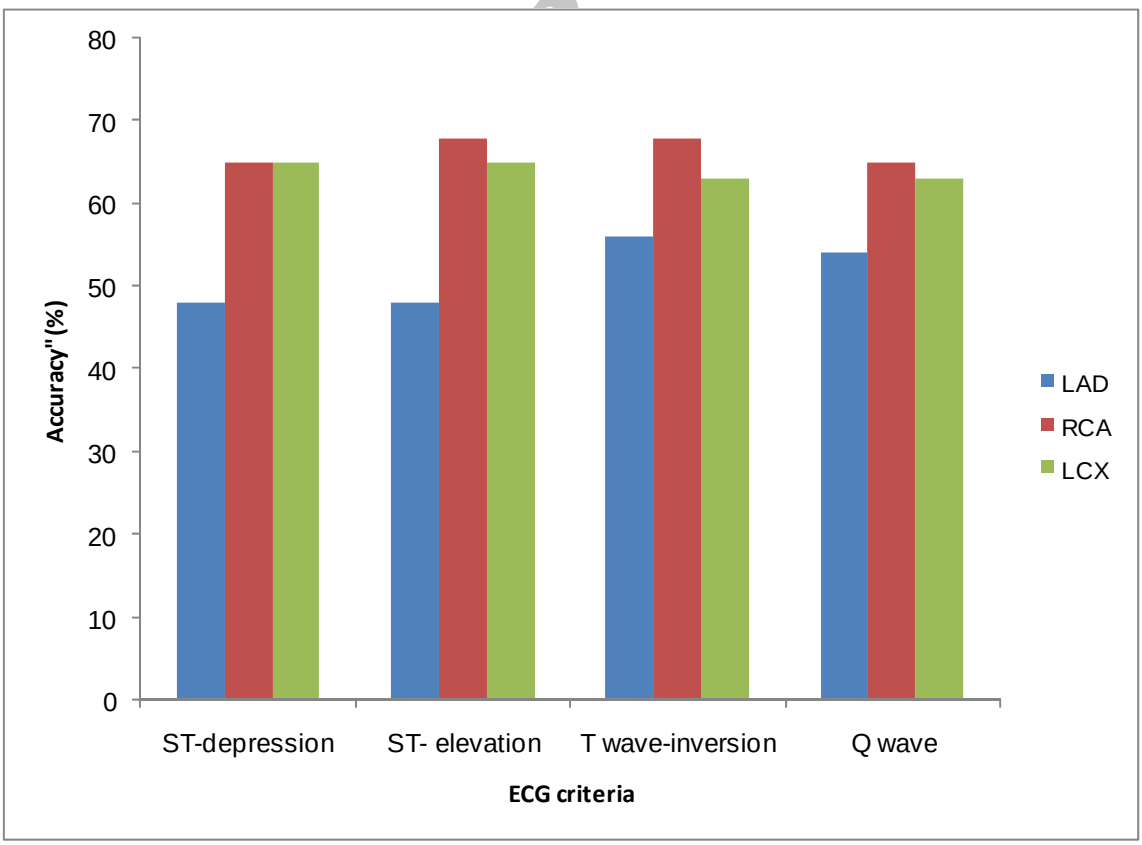

Figure 1. Accuracy of the parameters of ECG for predicting CAD based on arteries analysis

Table 4. ROC curve analysis of predictive power of electrocardiogram for diagnosis of coronary artery involvement in comparison with coronary angiography

Artery	Area	St. Error	95% Confidence Interval
LAD	0.586	0.028	0.530 – 0.642
RCA	0.524	0.031	0.463 – 0.585
LCX	0.530	0.031	0.470 – 0.591

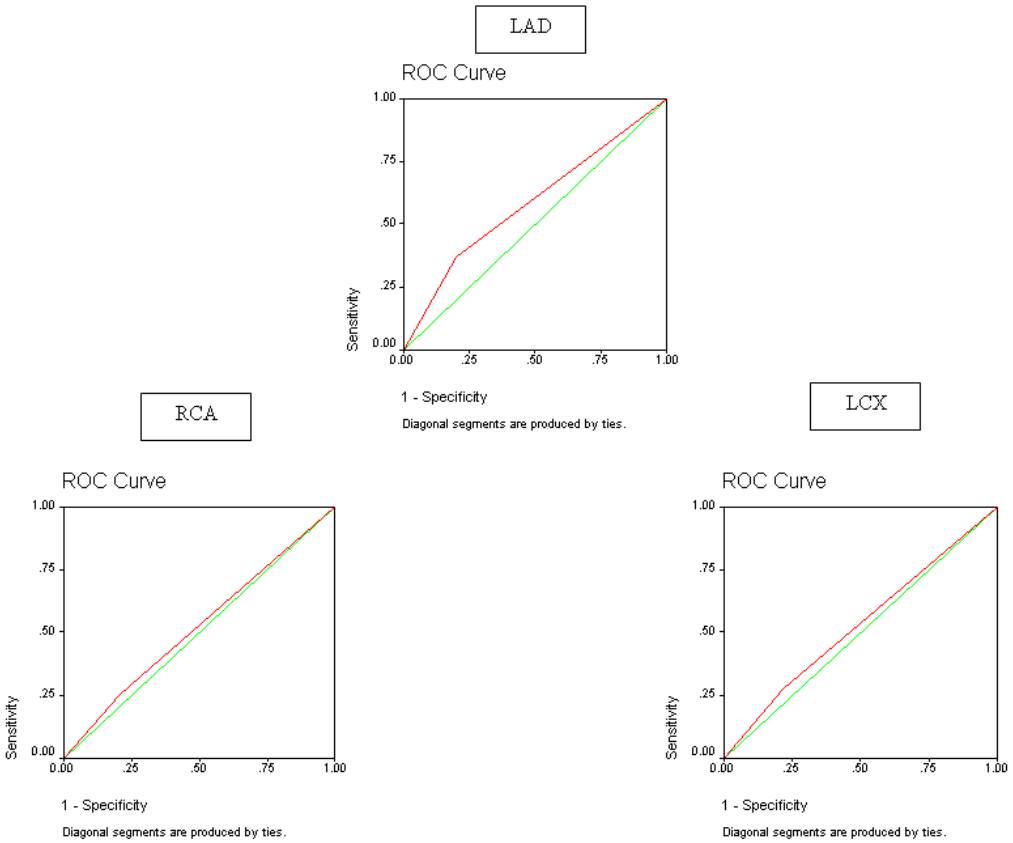

Figure 2. Receiver operator characteristic (ROC) curves were constructed to investigate the diagnostic power of the ECG per each coronary artery

Similar to the previous studies,[5, 6] our study showed low sensitivity as well as partial low specificity of ECG for predicting coronary arteries involvement. In current study, sensitivity of ECG for CAD diagnosis ranged between 25.8% and 37.3% and its specificity ranged from 79.0% to 79.9%. Some others considered a number of potential strategies for overcoming poor sensitivity of ECG such as using additional body surface leads in selected individuals.[10]

Based on our findings, each ECG parameters independently could poorly predict CAD with very low sensitivity; however, when considered together, predictive power was significantly increased. Similarly, Holubkov et al.[11] revealed that using at least two ECG parameters in any set of contiguous leads cause notable higher odds of significant angiographic CAD than those without concomitant ECG parameters changes. Therefore, judgment about the presence of CAD should be performed on the sum of ECG parameters findings.

ECG has been well known as an attractive method for patients' risk stratification. Recent studies found that the changes in ECG parame-

ters such as ST-segment depression and T-wave inversion could effectively predict long-term mortality and morbidity of patients with acute coronary syndrome and also those who undergoing cardiac revascularization.[12] Despite poor value of ECG to predict appearance of sudden cardiac attack, it may be potentially useful for predicting late outcome of cardiac diseases in comparison with invasive strategies that should be strongly considered.

Conflict of Interests

Authors have no conflict of interests.

Authors' Contributions

MM designed research and had primary responsibility for final content, SM conducted research, HR and MS analyzed data and wrote the paper. All authors read and approved the final manuscript. All authors have read and approved the content of the manuscript.

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