





## The relationship of the changes in lateral leads I and aVL in electrocardiogram with echocardiography and coronary angiography findings in patients with acute coronary syndrome

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### Original Article

#### Abstract

**BACKGROUND:** Electrocardiographic (ECG) study is a principle for the symptoms contributed to the acute myocardial infarction (AMI)/acute coronary syndrome (ACS). The diagnosis of involved coronary artery based on ECG changes is still a challenge. This study is aimed to evaluate the association of mere changes in I and aVL leads with the involved region found through echocardiography and involved coronary artery through angiography.

**METHODS:** This cross-sectional study was conducted on 100 patients referred with AMI/ACS symptoms that had mere ECG changes in I and aVL leads (ST elevation + Q wave/ST depression + inverted-T). Transthoracic echocardiography (TTE) and coronary angiography (CAG) were performed for the patients. The correlation of ECG with echocardiography and angiography was assessed.

**RESULTS:** Among the studied population, 39 patients (39%) were women with the mean  $\pm$  standard deviation (SD) of age of  $64.60 \pm 9.39$  years. There was no significant association between ECG changes in leads I and aVL with neither the stenosis of first diagonal (D1) coronary artery found through angiography ( $P = 0.580$ ) nor the mid-anterior wall dyskinesia found through echocardiography ( $P = 0.380$ ). A remarkable association between the echocardiographic findings representing mid-anterior wall ischemic dyskinesia with the stenosis of D1 coronary artery was detected ( $P < 0.001$ ). The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of 100%, 54.54%, 94.68%, and 100% were respectively found as the diagnostic values of mentioned factors.

**CONCLUSION:** Our findings showed significant association between D1 involvement and mid-anterior dyskinesia in echocardiography, while the changes in ECG were associated neither with echocardiographic nor angiographic outcomes.

**Keywords:** Acute Coronary Syndrome; Electrocardiography; Echocardiography; Coronary Angiography

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#### Introduction

Electrocardiographic (ECG) study is a principle for those presenting the symptoms that contributed to the acute myocardial infarction (AMI)/acute coronary syndrome (ACS).<sup>1</sup> The correlation of ST-segment elevation in 12-lead ECG with the territory of coronary arteries has been well evaluated among the patients with ST-elevated myocardial infarction (STEMI) but not non-STEMI.<sup>1-3</sup> On the

other hand, except for a few numbers of studies,

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practices on autopsies have presented a weak correlation of the extent of myocardial necrosis and its location with the ECG findings, Q waves in special.<sup>4</sup>

In AMI, the involvement of left anterior descending (LAD) artery is in direct association with the extent of necrosis and the patients' prognosis.<sup>5</sup> Moreover, the differentiation of LAD occlusion from the first diagonal (D1) artery through ECG interpretation is still an essential matter, as both can represent ECG changes in precordial leads and high lateral ones (I and aVL). The significance of this differentiation can be better clarified, considering the difference in the size of the necrosis affected by the involvement of either LAD or D1,<sup>6</sup> as D1 supplies high lateral and mid-anterior part of myocardium, while LAD distributes the blood to more huge areas overlapping some territories of D1 as well. Some authors believed that normal V1 lead accompanying with ST-segment, T wave, and Q wave changes in I and aVL leads may represent involvement of D1 coronary artery but not LAD.<sup>7</sup>

Due to the limited number of studies with controversial presentations, we aimed to evaluate the association of mere changes in I and aVL leads with the involved region found through echocardiography and involved coronary artery through angiography.

## Materials and Methods

This cross-sectional study was conducted on 100 patients referring with the ECG changes in the high lateral leads of I and aVL following the typical symptoms and signs of an ACS/AMI to Chamran Hospital, Isfahan, Iran, from May 2017 to April 2019. Patients older than 40 years who referred with suspicious symptoms of ACS/AMI including typical chest pain/angina, dyspnea, perspiration, nausea, vomiting, lightheadedness, signs of ACS/AMI including tachycardia, bradycardia, tachypnea, hypertension (HTN), hypotension, decreased oxygen saturation (O<sub>2</sub> sats), and dysrhythmia, and ECG changes in the leads I and aVL with normal ECG in other territories and underwent coronary angiography (CAG) and echocardiography were included. Complete left bundle branch block (LBBB), left ventricular (LV) hypertrophy, echocardiographic findings determining old myocardial Infarction (MI), and previous history of cardiac surgery were exclusion criteria of this study.

The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences (ethical number: 396011). The study

process was explained for the patients, and they were reassured about the confidentiality of their personal information. After that, the patients were requested to sign a written consent form of participation in this study. The participants were selected through convenience sampling until achieving the demanded population. Then the participants' age and gender were recorded in the study checklist. Following the patients' referral to the mentioned cardiology centers with the symptoms contributing to ACS/AMI, 12-lead ECG was taken from them immediately at the time of admission and then every 10 minutes until the third ECG was taken. The ECGs were interpreted by a skilled resident of cardiology assessing the axis deviations from normal ECG, Q wave + ST-segment elevation or ST-segment depression + T wave inversion in high lateral I and aVL leads merely. The most intensive changes found in the taken ECGs were included for further assessments. Q waves with the least duration of 30 milliseconds were considered for the study. Besides, ST-segment changes (whether elevation or depression) were defined as over 0.5 mV of elevation regarding the basic line in limb leads and more than 0.1 mV in precordial ones. The CAG was performed for the participants as well to evaluate involvement of other coronary arteries.

In addition, the echocardiography was done for all of the participants, and the mid-anterior involvement of myocardium following the recent ischemia (as a result of D1 coronary artery stenosis), considering wall motion disorders including mid-anterior hypokinesia and/or dyskinesia, was assessed. The echocardiography was performed based on Simpson method. In order to minimize the interobserver bias, all of the echocardiography and CAG were performed by a single expert interventional cardiologist.

*Statistical analysis:* Obtained data were entered into the SPSS software (version 22, IBM Corporation, Armonk, NY, USA) for the analysis. Continuous variables were described using mean  $\pm$  standard deviation (SD) and categorical variables using numbers and percentage. Chi-square test was used to compare frequency for categorical variables. Besides, the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were measured for the correlation of ECG changes with the involved ischemic coronary artery. P-value of less than 0.050 was considered significant.

## Results

The total number of 100 patients with mere ECG

changes in I and aVL following ACS/AMI but no other leads were included. Participants underwent echocardiography in order to find the myocardial wall motion dysfunctions. Among the assessed patients with ACS/AMI, 39 ones (39%) were women. The mean  $\pm$  SD of age of all participants was  $64.67 \pm 9.39$  years [ $64.84 \pm 8.61$  years (range: 46-81 years) in women and  $64.55 \pm 9.92$  years (range: 43-85 years) in men]. Q waves + ST-elevation were detected in I and aVL leads of ECGs taken from 16 patients (16%) and the latter 84 ones (84%) had ST-segment depression + T wave inversion changes in the ECG. Table 1 summarized the baseline characteristics and CAG and echocardiographic findings. The ECG changes in leads I and aVL had no statistical association with the stenosis of D1 coronary artery found through CAG ( $P = 0.580$ ) (Table 2).

**Table 1.** Baseline characteristics, coronary angiography (CAG), and echocardiography findings of the patients

Variables	Number (%)
Sex	
Women	39 (39)
Men	61 (61)
DM	28 (28)
HTN	42 (42)
Former or current smoker	42 (42)
Involvement of diagonal on CAG	94 (94)
Mid-anterior wall ischemic changes	89 (89)
	<b>Mean <math>\pm</math> SD</b>
Age (year)	$64.67 \pm 9.39$
Women	$64.84 \pm 8.61$
Men	$64.55 \pm 9.92$
BMI ( $\text{kg}/\text{m}^2$ )	$26.10 \pm 5.30$
LVEF (%)	$38.30 \pm 12.30$

DM: Diabetes mellitus; HTN: Hypertension; SD: standard deviation; CAG: Coronary angiography; BMI: Body mass index; LVEF: Left ventricular ejection fraction

The echocardiography study of patients revealed no statistical association between the high lateral ECG changes (changes found only in leads I and aVL) and the evidence presenting mid-anterior wall dyskinesia ( $P = 0.380$ ) (Table 3). We observed a remarkable association between the echocardiographic findings representing mid-anterior

wall ischemic dyskinesia with the CAG results regarding the stenotic status of D1 coronary artery ( $P < 0.001$ ) (Table 4).

The sensitivity, specificity, PPV, and NPV of ECG changes in I and aVL leads for detection of mid-anterior wall ischemic dyskinesia in echocardiography were 100%, 54.54%, 94.68%, and 100%, respectively.

## Discussion

Although it has been well established that the affected territory of the coronary artery is in correlation with the ECG changes among the STEMI cases, the anatomical pattern of the coronary arteries may be affected by the ethnicities and races.<sup>4</sup> In addition, despite the findings in favor of the correlation between ECG changes in the leads I and aVL with the occluded D1 coronary artery, this correlation about the apparent site of anterior territory involvement is still a challenge.<sup>6</sup> In the current study, we observed that ECG changes in the high lateral leads (while other leads represented no changes) were in association with the findings of neither CAG nor echocardiography, representing the mid-anterior wall motion ischemic akinetic or dyskinetic changes. This may have occurred as we included patients with ECG changes including Q wave plus ST-segment elevation and also, ST-segment depression plus inverted T waves.

Our finding showed a significant association of echocardiography findings presenting mid-anterior wall ischemic dyskinetic movements with the involvement of D1 but no other coronary arteries found in the CAG. This correlation had a sensitivity of 100%, the specificity of 54.54%, and PPV of 100% as well. Therefore, echocardiography findings contributed to the mid-anterior wall motion dysfunction, as a noninvasive modality, are a valuable means for the correct diagnosis of D1 coronary artery territory involvement.

In the literature, most of the previous studies have assessed the association of ECG changes, including ST-elevation, T inversion, and Q waves with the site of coronary artery occlusion found in the angiography.<sup>8-10</sup>

**Table 2.** The association of electrocardiographic (ECG) changes with the first diagonal (D1) coronary artery stenosis through coronary angiography (CAG) study

Variables	D1 coronary artery stenosis		P
	No	Yes	
ECG			0.580
Q wave + ST-segment elevation	0 (0)	16 (16)	
ST-segment depression + T wave inversion	6 (6)	78 (78)	

Data are presented as number and percentage  
ECG: Electrocardiography; D1: First diagonal

**Table 3.** The association of electrocardiographic (ECG) changes with the mid-anterior ischemic changes of cardiac echocardiography

Variables	Mid-anterior wall ischemic changes		P
	No	Yes	
ECG			
Q wave + ST-segment elevation	0 (0)	16 (16)	0.120
ST-segment depression + T wave inversion	11 (11)	73 (73)	

Data are presented as number and percentage

ECG: Electrocardiography

**Table 4.** The association of first diagonal (D1) coronary artery stenosis through coronary artery angiography with the mid-anterior wall ischemic changes through echocardiography

Variables		Mid-anterior wall ischemic changes		P
		No	Yes	
D1 coronary artery stenosis	Yes	5 (5)	89 (89)	< 0.001
	No	6 (6)	0 (0)	

Data are presented as number and percentage

D1: First diagonal

In this term, the authors have presented that changes in mentioned ECG patterns in V1-V4 leads and anterior and anteroseptal patterns were in accordance with LAD stenosis.<sup>11</sup> In rare cases, ST-elevation in V1-V4 leads is associated with the right coronary artery (RCA) occlusion due to concurrent right ventricular (RV) infarction.<sup>2</sup> In inferior MIs, changes presented in inferior leads of II, III, and aVF that may be representative of either left circumflex artery (LCX) or RCA in the majority of the population.<sup>1</sup> ST-elevation in precordial V4-V6 leads without any change in the V1-V3 leads was in correlation with the significant stenosis of LCX or distal diagonal branch rather than the main LAD coronary artery.<sup>2</sup> Nevertheless, findings regarding the D1 artery are limited and controversial. There are studies theoretically presenting that the ST-segment elevation in the lead aVL is in association with the D1 coronary artery occlusion, but the value of this finding has not been well established. Therefore, authors were searching for other determinants showing the D1 involvement following AMI.<sup>12-14</sup> Contrary to our study, Kotoku et al. assessed aVL and V1 leads for the determination of D1 artery involvement. They presented that ST-elevation in aVL accompanying with less than 1 mm of elevation in lead V1 could remarkably present the D1 involvement detected through CAG.<sup>6</sup> As mentioned above, these findings were declared by Iwasaki et al. as well in 1994.<sup>7</sup> Another study by Abu Fanne et al. in 2019 presented that ST-elevation in leads I, aVL, and V2 was remarkably associated with the lateral wall

involvement representing the D1 occlusion. They went on that additional reciprocal changes in the inferior lead plus normal V3-V5 were firmly in favor of D1 involvement.<sup>15</sup> The other study by Ghosh et al. in contrast to our study declared that Q wave in lead II or ST-elevation in the lead V2 represented proximal occlusion of D1 with considerable specificity of 90% but a low sensitivity.<sup>8</sup>

The association of ECG changes with regional valve motion abnormalities has been assessed previously as well. Golovchiner et al. have declared considerable specificity and sensitivity of ST-segment changes in precordial leads whether elevation or depression in the both global and regional wall motion abnormalities detection in mid-posterior segments using echocardiography.<sup>16</sup> Similar to our study, Czechowska et al. found no association between regional wall motion abnormalities through echocardiography and ST-segment changes in leads I and aVL,<sup>17</sup> while the other study by Porter et al. presented that ST elevation was in direct correlation with abnormal regional wall motion of basal anterior segment.<sup>18</sup> Considering the controversial presentations of various studies, further evaluations are strongly recommended. To the best of our knowledge, this is the first study assessing the concordance of angiography findings representing only D1 stenosis with echocardiographic assessments about the extent of cardiac wall abnormal motions. Alonso-Gomez et al. conducted a study on patients who had absolute diagnosis of LAD involvement using angiography. They evaluated the value of stress echocardiography and compared it with the value of ECG changes in the territory of LAD. They presented remarkable specificity and sensitivity of 74% and 92%, respectively, for echocardiographic findings representing anterior myocardial wall movement dysfunctions. The values were less for ECG as 74% of sensitivity and only 26% of specificity.<sup>19</sup> The other study by Peteiro et al. in 2003 revealed significant specificity (79%) and sensitivity (79%) of exercise echocardiography with the involved artery found in CAG. The exercise echocardiography rather than usual

echocardiography was required in their study as they performed angiography within four months following ischemia.<sup>20</sup> In the other study, Esmailzadeh et al. did not assess the values of echocardiography to correctly diagnose the involved territory found either by CAG or ECG; they performed echocardiography in acute phases following AMI and declared remarkable valuable findings representing the extension and localization of myocardium injury.<sup>21</sup>

In summary, we assessed the CAG and echocardiography findings among the patients representing AMI/ACS symptoms who had ECG changes only in aVL and I leads. In the current study, we found significant correlation between D1 coronary artery involvement with the mid-anterior wall dyskinesia, while no association was found between mere involvement of leads aVL and I with neither angiography nor echocardiography.

### Conclusion

Based on our study, there was no remarkable association between leads I and aVL changes following ACS/AMI with neither echocardiography study nor angiography assessment, while the mid-anterior segment regional wall motion abnormalities were in direct correlation with the CAG representing mere involvement of D1 but not LAD with considerable sensitivity of 100% and specificity of 54.54%. Due to the value of echocardiography as a noninvasive modality and limited number of studies assessing this issue, further studies are strongly recommended.

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### Conflict of Interests

Authors have no conflict of interests.

### References

- Sanaani A, Yandrapalli S, Jolly G, Paudel R, Cooper HA, Aronow WS. Correlation between electrocardiographic changes and coronary findings in patients with acute myocardial infarction and single-vessel disease. *Ann Transl Med* 2017; 5(17): 347.
- Birnbaum Y, Drew BJ. The electrocardiogram in ST elevation acute myocardial infarction: Correlation with coronary anatomy and prognosis. *Postgrad Med J* 2003; 79(935): 490-504.
- Azab D, Zahran ME, Elmahmoudy A. Initial T wave morphology in the chest leads in patients presenting with anterior ST-segment elevation myocardial infarction and its correlation with spontaneous reperfusion of the left anterior descending coronary artery. *Int J Cardiovasc Acad* 2019; 5(2): 52-7.
- Gaude RP, Gautam DK, Jain D, Singh GP, Das P, Choudhury AK, et al. Study of coronary angiographic correlation with electrocardiography in patients of acute coronary syndrome-ST-elevation myocardial infarction. *Heart India* 2018; 6(4): 115-22.
- Engelen DJ, Gorgels AP, Cheriex EC, De Muinck ED, Ophuis AJ, Dassen WR, et al. Value of the electrocardiogram in localizing the occlusion site in the left anterior descending coronary artery in acute anterior myocardial infarction. *J Am Coll Cardiol* 1999; 34(2): 389-95.
- Kotoku M, Tamura A, Shinozaki K, Abe Y, Watanabe T, Kadota J. Electrocardiographic differentiation between occlusion of the first diagonal branch and occlusion of the left anterior descending coronary artery. *J Electrocardiol* 2009; 42(5): 440-4.
- Iwasaki K, Kusachi S, Kita T, Taniguchi G. Prediction of isolated first diagonal branch occlusion by 12-lead electrocardiography: ST segment shift in leads I and aVL. *J Am Coll Cardiol* 1994; 23(7): 1557-61.
- Ghosh B, Indurkar M, Jain MK. ECG: A simple noninvasive tool to localize culprit vessel occlusion site in acute STEMI. *Indian Journal of Clinical Practice* 2013; 23(10): 590-5.
- Verouden NJ, Barwari K, Koch KT, Henriques JP, Baan J, van der Schaaf RJ, et al. Distinguishing the right coronary artery from the left circumflex coronary artery as the infarct-related artery in patients undergoing primary percutaneous coronary intervention for acute inferior myocardial infarction. *Europace* 2009; 11(11): 1517-21.
- Hurst JW. *Hurst's the Heart*. New York, NY: McGraw-Hill, Medical Pub; 2004.
- Zimetbaum PJ, Josephson ME. Use of the electrocardiogram in acute myocardial infarction. *N Engl J Med* 2003; 348(10): 933-40.
- Allencherril J, Fakhri Y, Engblom H, Heiberg E, Carlsson M, Dubois-Rande JL, et al. The significance of ST-elevation in aVL in anterolateral myocardial infarction: An assessment by cardiac magnetic resonance imaging. *Ann Noninvasive Electrocardiol* 2018; 23(6): e12580.
- Yoshino H, Kachi E, Shimizu H, Taniuchi M, Yano K, Udagawa H, et al. Severity of residual stenosis of infarct-related lesion and left ventricular function after single-vessel anterior wall myocardial infarction: Implication of ST-segment elevation in lead aVL of the admission electrocardiograms. *Clin Cardiol* 2000; 23(3): 175-80.
- Arbane M, Goy JJ. Prediction of the site of total occlusion in the left anterior descending coronary

- artery using admission electrocardiogram in anterior wall acute myocardial infarction. *Am J Cardiol* 2000; 85(4): 487-91, A10.
15. Abu Fanne R, Kleiner Shochat M, Shotan A, Frimerman A, Maraga E, Amsalem N, et al. Acute diagonal-induced ST-elevation myocardial infarction and electrocardiogram-guidance in the era of primary coronary intervention: New insights into an old tool. *Eur Heart J Acute Cardiovasc Care* 2020; 9(8): 827-35.
  16. Golovchiner G, Matz I, Iakobishvili Z, Porter A, Strasberg B, Solodky A, et al. Correlation between the electrocardiogram and regional wall motion abnormalities as detected by echocardiography in first inferior acute myocardial infarction. *Cardiology* 2002; 98(1-2): 81-91.
  17. Czechowska M, Kornacewicz-Jach Z, Goracy J, Przybycien K, Zielonka J, Lewandowski M, et al. The value of the initial electrocardiogram in the evaluation of an acutely ischaemic area in anterior myocardial infarction. *Cardiol J* 2006; 13(7): 570-7.
  18. Porter A, Wyshesky A, Strasberg B, Vaturi M, Solodky A, Imbar S, et al. Correlation between the admission electrocardiogram and regional wall motion abnormalities as detected by echocardiography in anterior acute myocardial infarction. *Cardiology* 2000; 94(2): 118-26.
  19. Alonso-Gomez AM, Bello MC, Fernandez MA, Torres A, Alfageme M, Aizpuru F, et al. [Stress echocardiography in the identification of left anterior descending coronary artery disease in patients with inferior myocardial infarction and a positive exercise electrocardiography result]. *Rev Esp Cardiol* 2006; 59(6): 545-52.
  20. Peteiro J, Monserrat L, Perez R, Vazquez E, Vazquez JM, Castro-Beiras A. Accuracy of peak treadmill exercise echocardiography to detect multivessel coronary artery disease: Comparison with post-exercise echocardiography. *Eur J Echocardiogr* 2003; 4(3): 182-90.
  21. Esmailzadeh M, Parsaee M, Maleki M. The role of echocardiography in coronary artery disease and acute myocardial infarction. *J Tehran Heart Cent* 2013; 8(1): 1-13.