Original Article

Correlation of ECG Changes with Coronary Angiographic Findings in Acute Inferior Myocardial Infarction

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Abstract

The determination of infarct related artery in acute inferior myocardial infarction is extremely important for the prediction the amount of myocardium at risk and guide decisions regarding urgency of revascularization. Urgent decision may facilitate management and prevention of complication. Our objective was to Identification of the infarct related artery involving either right coronary artery (RCA) or left circumflex artery (LCX) in acute inferior wall myocardial infarction using electrocardiographic criteria and comparing with angiographic finding.

This prospective, observational study was done in Chittagong Medical College Hospital from June 2013 to May 2014. A total of 112 Patients with acute inferior myocardial infarction were included in this study. The electrocardiogram of these patients evaluated for ST segment elevation in lead III exceeding that in lead II (i.e. a ratio of ST elevation in lead III/elevation in lead II > 1) and S/R wave ratio > 0.33 plus ST segment depression > 1 mm in lead aVL as a prediction for right coronary artery occlusion. If criteria are negative, LCX obstruction is likely. Coronary angiogram was done within 2-6 weeks in cath lab, department of cardiology, CMCH to identify the culprit artery. The infarct related artery (IRA) was identified from total occlusion or significant stenosis (> 70%) of the RCA or LCX or their major branches, or from arteriographic evidence of intraluminal thrombosis. To minimize the chance of misclassifying the culprit artery, patients with significant stenosis of both the RCA and the LCX were excluded from the study. The study population consisted of 112 patients (94 male and 18 female) with a mean ± SD age of 51 ± 8.6 years. On coronary angiography, the culprit artery was shown to be the RCA in 92 patients and the LCX in 20 patients. It was evident that the degree of ST segment elevation in lead III was significantly higher in right coronary artery group (92 patients) vs left circumflex group (20 patients) 3.16±1.14mm vs 1.35±0.24mm (p<0.001) respectively. While its comparable in lead II 2.18±0.95mm vs 1.7±0.34mm (p>0.05). In respect to leads AVL, we found that deeper ST segment depression was in right coronary artery group as compared to left circumflex group 1.11±0.25mm vs 0.2 ±0.34mm (p<0.001). ECG parameters for implicating the RCA were a higher ST elevation in lead III than lead II (specificity 98%, sensitivity 97%) and an S/R wave ratio > 0.33 plus ST segment depression > 1 mm in lead aVL (specificity 96%, sensitivity 95%). Absence of these criteria was associated with LCX occlusion (specificity 100%, sensitivity 85%). It is possible to predict the culprit artery whether right coronary artery or left circumflex by examining the surface electrocardiography in patients with acute inferior myocardial infarction.

Keywords: RCA-Right coronary artery, LCX- Left circumflex artery, SD- Standard deviation, IRA-infarct related artery, CMCH- Chittagong Medical College Hospital.

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Introduction

Coronary heart disease is a worldwide health epidemic. Worldwide 30 percent of all deaths can be attributed to cardiovascular disease of which more than half are caused by coronary heart disease. Globally of those dying from cardiovascular disease, 80 percent are in developing countries[1]. By 2020, cardiovascular disease will causes one of every three deaths worldwide. Coronary heart disease is the leading cause of cardiovascular disease.

Every minute an American dies of coronary artery disease. About 38 per cent of people experience an acute coronary event[2]. Acute myocardial infarction (AMI) is one of the most common presentations of CAD.

Received: 13 May 2017 Accepted: 21 October 2017

In acute Inferior Myocardial Infarction, the infarct related artery is usually the right coronary artery (RCA) and less often the left circumflex coronary artery (LCX)[3]. The incidence of mortality and complications are high in patients of acute inferior wall MI with right ventricular involvement. In the presence of complications (hypotension, bradycardia, right heart failure, shock and arrhythmias etc.), Right Coronary artery (RCA) is generally the infarct related artery[4].

The ECG is non invasive, affordable, easily available and essentially without any known adverse effects. ECG is generally used to diagnose myocardial infarction. However, it can also be used to predict the culprit artery in patients with myocardial infarction. Early prediction of infarct related artery by ECG can recognize the amount of myocardium at risk and guide decisions regarding urgency of revascularization. Urgent decision may facilitate management and prevention of complication.

In Electrocardiographic (ECG), the standard lead III is oriented to the right inferior segment, whereas lead II is oriented principally to the left inferior segment and also to the inferior region of the left lateral part of the superior wall of the ventricle. Consequently, lead III is more influenced by right coronary artery related AMI and lead II by Left Circumflex artery (LCX) related AMI[3]. ST segment elevation more in lead III than lead II (ratio >1) and S/R wave ratio >0.033 plus ST depression >1 in lead aVL is suggestive Right Coronary Artery and absence of those criteria is suggestive Left Circumflex Artery involvement[3].

Although coronary angiography is the "gold standard" for determining the infarct-related artery in acute myocardial infarction, the ECG can be a useful tool in identifying which artery is involved at the first point of care. We can confirm the ECG prediction by angiogram.

In many Centers of our country, early intervention is not possible. By examining ECG, we can predict the infarct related artery and upcoming complications. For these groups, we can refer them to a center where early revascularization facility is present.

Most of the patients of greater Noakhali, Hilltract, Cox's Bazar and Chittagong district seek treatment in Chittagong Medical College Hospital as a tertiary care hospital. This study will be done in this hospital of these selected people. So study can be represented a larger population of Bangladesh.

Materials and Methods

Patients

It was a prospective, observational study. The study population consisted of patients with a diagnosis of acute inferior myocardial infarctions, who were admitted to coronary care unit, Department of Cardiology of Chittagong Medical College Hospital between June 2013 and May 2014 and who subsequently underwent coronary angiography within 2-6 weeks. A total of 112 Patients with acute inferior myocardial infarction were included in this study. A patient with acute inferior myocardial infarction was recognized first from history, examination and ECG. Other history was taken from the patients regarding the age, sex, hypertension, diabetes, smoking and others risk factors.

A diagnosis of inferior wall AMI was made on the basis of: chest pain lasting > 30 min; ST-segment elevation > 1 mm in at least two of the three inferior leads (II, III and aVF); and elevation or fall of Troponin-I. Patients with a history of previous AMI or double wall AMI, dependent on pacemaker, prior coronary artery bypass surgery or percutaneous transmural coronary angioplasty showing ECG evidence of bundle branch block or left ventricular hypertrophy were excluded from the study. All patients gave informed written consent and the Medical Faculty of Chittagong University Ethics Committee approved the study.

ECG

Standard Twelve leads electrocardiography were recorded at a paper speed 25 mm/s with amplitude of 10mm/mv, any STsegment deviation from isoelectric line (T-P segment) was measured to nearest 0.5mm at 80 m sec after the J point. Serial ECGs performed on admission, within 6 h of the onset of chest pain. The following ECG changes were assessed: ST-segment elevation in lead III exceeding that in lead II, defined as a ratio of ST elevation in lead III/elevation in lead II > 1 (Criterion A); ST-segment depression in lead aVL, defined as > 1 mm deviation from the isoelectric line; an S/R wave ratio in lead aVL > 0.33 (Criterion B).

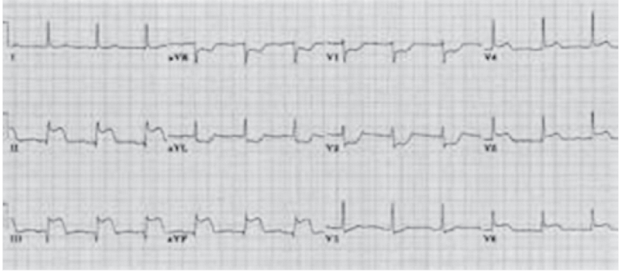

Figure-1: ECG showing criteria A and B positive.

Criteria A: ST elevation in Lead III more than in Lead II and Criteria B: ST-segment depression in lead aVL, defined as > 1 mm deviation from the isoelectric line; an S/R wave ratio in lead aVL > 0.33.

Prediction of the infarct related artery involving either right coronary artery (RCA) or left circumflex artery (LCX) by ECG criterion A and criterion B and comparing with angiographic finding.

Coronary Angiography

The coronary angiography was done by percutanes Judkin's technique via femoral route in cath lab,

department of cardiology, CMCH to identify the culprit artery. Coronary angiography was performed between 2 week and 6 weeks after the infarction. Coronary angiography films were reviewed by two investigators who were blinded to the ECG findings. The infarct related artery was identified from total occlusion or significant stenosis (> 70%) of the RCA or LCX or their major branches, or from arteriographic evidence of intraluminal thrombosis.

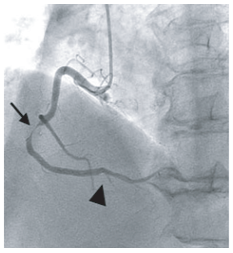

Figure-2: CAG of RCA involvement.

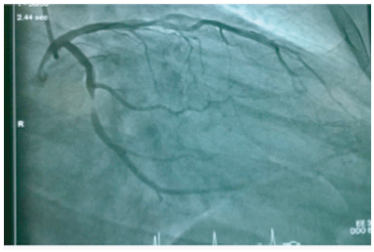

Figure-3: CAG of RCA involvement.

To minimize the chance of misclassifying the culprit artery, patients with significant stenosis of both the RCA and the LCX, Significant lesion in LAD and any Ectatic vessels were excluded from the study.

Statistical Analysis

The statistical significance for observed differences was assessed by student T test, test of proportions, correlation was established by Spearman's correlation coefficient test & analysis of variance used to compare differences between variables. P value < 0.05 was considered statistically significant, P value < 0.001 was considered statistically extremely significant, P value > 0.05 was considered statistically not significant.

Results and Observations

The study population involved 112 patients (94 males and 18 female) with a mean ± SD age of 51.79 ± 8.68 years with the diagnosis of acute inferior myocardial infarction.

The ECG findings were classified according to two patterns of changes: criterion A consisted of ST segment elevation in lead III exceeding that in lead II (i.e. a ratio of ST elevation in lead III/elevation in lead II > 1 and criterion B consisted of ST segment depression in lead aVL more than or equal to 1 mm and S/R wave ratio > 0.33 (fig.-1).

It was evident that the degree of ST segment elevation in lead III was significantly higher in right coronary artery group (92 patients) vs left circumflex group (20 patients) 3.16±1.14mm vs 1.35±0.24mm (p<0.001) respectively. While its comparable in lead II 2.18±0.95mm vs 1.7±0.34mm (p>0.05) (table-I). In respect to leads AVL, we found that deeper ST segment depression was in right coronary artery group as compared to left circumflex group 1.11±0.25mm vs 0.2 ±0.34mm (p<0.001).

Table-I: Electrocardiograph findings in relation to culprit artery. (N=112)

Electrocardiographic finding		Right coronary artery (n=92) mean±(SD)	Left circumflex artery (n=20) mean±(SD)	P. value
ST segment elevation in mm	II	2.18±(0.95)	1.7±(0.34)	> 0.05^{NS}
ST segment elevation in mm	III	3.16±(1.14)	1.35±(0.24)	> <0.001^{S}
ST segment depression in mm	AVL	1.11±(0.25)	0.2±(0.34)	> <0.001^{S}

Correlation was established by t- test, Significant =^{S}, Non Significant =^{NS}, N= Number of study population, n= Number in each group, mm = millimeter, < =less than, >=more than, SD=Standard deviation, II= Lead II, III=Lead-III, AVL= Lead AVL

On coronary angiography, the culprit artery was found to be the RCA in 82.1% (92) patients and the LCX in 17.85% (20) patients out of 112 patients.

Identification of infarct related artery between electrocardiogram (ECG) findings and the culprit artery demonstrated by angiography in 112 patients with acute myocardial infarction. Correlation of electrocardiogram (ECG) changes with angiographic findings shown in table-II.

Table-II: Correlation of electrocardiogram (ECG) changes with angiographic findings. (N-112)

Infarct Related Artery					
ECG Finding	RCA (n=92)		LCX (n-20)		
	Number (n)	Percent (%)	Number (n)	Percent(%)	P. value
Criteria A positive	90	97	1	5	<0.001^{S}
Criteria B positive	88	95	1	5	<0.001^{S}
Criteria A and B both positive	88	95	0	0	<0.001^{S}
Criteria A and B both negative	0	0	18	90	<0.001^{S}

Correlation was established by Spearman's correlation coefficient test, Significant =^{S}, Non Significant =^{NS}, RCA=right coronary artery, LCX=left circumflex artery, N= Number of study population, < =less than, >=more than, n= Number in each group, % = percentage,
Criterion A= ST segment elevation in lead III exceeding that in lead II (i.e. a ratio of ST elevation in lead III/elevation in lead II > 1).
Criteria B= ST segment depression in lead aVL more than or equal to 1 mm. and S/R wave ratio > 0.33.

The sensitivity, specificity and positive and negative predictive values of the two ECG criteria and their combinations are shown in table-III. The results did not change with variation in the obstruction site along the coronary artery (proximal versus distal; data not shown).

Table-III: Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the electrocardiogram (ECG) criteria, alone and in combination. (N=112)

ECG Finding	Infarct Related Artery	Sensitivity %	Specificity %	PPV %	NPV %
Criteria A positive	RCA	97	98	98	90
Criteria B positive	RCA	95	96	98	82
Criteria A and B both positive	RCA	95	100	100	83
Criteria A and B both negative	RCA	0	11	0	100
	LCX	85	100	100	50

RCA: Right coronary artery; LCX: Left circumflex artery, PPV= Positive predictive value, NPV= Negative predictive value, N= Number of study population, n= Number in each group, %= Percentage,
Criterion A= ST segment elevation in lead III exceeding that in lead II (i.e. a ratio of ST elevation in lead III/elevation in lead II > 1).
Criteria B= ST segment depression in lead aVL more than or equal to 1 mm. and S/R wave ratio > 0.33.

Table- III shown that ST segment elevation in lead III more than lead II was sensitive 96% and specific 93% for right coronary artery occlusion and also ST segment depression in lead aVL more than lead I was also sensitive 97% and specific 90% for right coronary artery occlusion group.

We found that, in patients with inferior wall AMI, both criterion A and criterion B were sensitive and specific markers for RCA but not for LCX obstruction. If both criteria are negative, LCX obstruction is likely.

Discussion

In present study we compared various ECG criteria for diagnosis of infract related artery in inferior wall MI with angiographic findings as gold standard. Among the 112

patients with acute inferior MI, We found the culprit lesion was in the RCA in 92 patients and in the LCX in 20 patients, a ratio of 4.6:1.

Other studies of patients with acute inferior MI have found RCA to LCX ratios ranging from 2.2:1 to 7.0:1 and averaging 3.9:1[5,6,7,8]. Thus, the RCA is much more likely than the LCX to contain the culprit lesion in patients with acute inferior MI.

Rarely, acute inferior MI may result from occlusion of the recurrent LAD branch which is the terminal portion of a "wrap-around" LAD, but this was not the case in any of patients in this study. Occasional studies also have included a few patients with normal coronary arteriographic findings and others in whom the culprit lesion could not be identified. The patients with normal angiography and in whom culprit lesion couldn't be identified have been excluded.

Previous studies have already described various ECG signs to identify the infarct-related artery. For instance (1) ST-segment depression in lead I ≥ 0.5 mm (2) ratio of ST-segment elevation in II/III < 1 (3) ratio of ST-segment depression in V3/ST-segment elevation in III < 0.5 (4) ST-segment elevation in V4R. (5) ST-segment depression in aVL > I (6) T-wave magnitude in III > II[9] predict RCA occlusion. By contrast (1) ST-segment isoelectric or elevation in lead I (2) ratio of ST-segment elevation in II/III > 1 (3) ratio of ST-segment depression in V3/ST-segment elevation in III > 1.25 predicts LCX occlusion. Fiol and colleagues developed an algorithm, which was able to predict proximal RCA and distal RCA and LCX occlusion with high accuracy[10].

Further Radhakrishnan and colleagues had shown that the amount of ST-segment depression in lead aVR, also to be an accurate predictor of involved artery in inferior MI[11]. ST-segment elevation in lead III ≥2.5mm and the ratio of ST-segment in V2/V3 ≥1 are very specific signs for RCA occlusion[12].

In the present study it was found that ST segment elevation in lead III exceeding that in lead II, that is a ratio of elevation in lead III/elevation in lead II > 1 (criterion A), had a high specificity and sensitivity for RCA occlusion. ECG (Criteria A) giving a sensitivity of 95%, a specificity of 96%, a positive predictive value of 98% and a negative predictive value of 82% for RCA involvement.

These result is consistent with research done by Radhakrishnan Naair, D. Luke Glancy shows a sensitivity of 96%, a specificity of 40%, a positive predictive value of 89% and a negative predictive value of 67% for RCA involvement[13].

These results suggest that a ratio of ST elevation in lead III/ ST elevation in lead II > 1 is an important predictor of RCA occlusion, a finding consistent with that of previous studies as Zimetbaum and colleagues, who had showed that a higher ST segment elevation in lead III than in lead II was only seen in RCA occlusion, and Chia BL, Yip JW, Tan HC, Lim YT reported that ST segment elevation in lead III greater than that in lead II was valuable in predicting RCA occlusion.

Similar criteria to predict the RCA occlusion in acute inferior wall MI was also confirmed by Yokousoglu and colleagues with a positive predictive value of 78.9%, sensitivity of 89.4% and specificity of 50%. Our study showed similar results.

In addition, it was found that ST depression ≥ 1 mm in lead aVL (criterion B) was of value in predicting RCA occlusion. Criterion B was positive in of patients with RCA lesion, giving a sensitivity of 97%, a specificity of 98%, a positive predictive value of 98% and a negative predictive value of 90% for RCA involvement.

These results suggest that an S/R wave ratio >0.33 plus ST depression ≥ 1 mm in lead aVL is also a useful predictor of RCA occlusion. Again, this finding is in agreement with previous studies. Bailey and colleagues[14], reported that ST segment depression in lead I and aVL was only observed during RCA occlusion. Birnbaum et al.[15] reported that ST segment depression in lead aVL was a sensitive early ECG sign of RCA occlusion. Berry and colleagues also showed that ST depression in both aVL and V1 was a marker of RCA occlusion in acute inferior wall MI. Fiol Mikual and colleagues showed that the sum of ST depression in I and aVL compared to criteria based on ST depression in aVL was more specific for RCA. Similar results were obtained in our study.

Similarly Huey and colleagues[16] demonstrated ST depression in lead I in 22% of their LCX patients and 59% of their RCA patients, whereas Kontos and colleagues[17] reported this finding in 28% of their LCX patients and 58% of their RCA patients. Shu-Fen Wung and colleagues[18] have shown that ST-segment elevation in the right ventricular leads and inferior leads occurred more often during occlusion of the right coronary artery than during occlusion of the circumflex artery. They further concluded that ST-segment depression in lead aVL is highly suggestive of right coronary occlusion, whereas ST-segment elevation in posterior leads without depression of the ST segment in lead aVL is highly sensitive and specific for occlusion of the left circumflex artery.

Most studies carried out so far have considered only one ECG criteria. The main aim of this study was to evaluate the value of combining criterion A and criteria B for predicting RCA involvement, as well as their value when both negative for predicting LCX involvement.

The use of combined criteria gave a high specificity and sensitivity for both RCA and LCX occlusions. Both criterion A and criterion B were positive in 88 patients (95%) with RCA occlusion but only 0(0%) patients with

LCX had this finding, giving a sensitivity of 95%, a specificity of 100%, a positive predictive value of 100% and a negative predictive value of 83% for RCA involvement.

Both criteria were negative in 18 patients (90%) with LCX occlusion but only zero patients with RCA had this finding, giving a sensitivity of 85% and a specificity of 100% for LCX involvement. In addition E. Bayram and colleagues[19] had suggested that a ratio of ST elevation in lead III/ST elevation in lead II > 1, and an S/R wave ratio > 0.33 plus ST depression > 1 mm in lead aVL, are specific and sensitive markers of RCA occlusion.

Conclusion

It is possible to predict the culprit artery whether right coronary artery or left circumflex by examining the surface electrocardiography in patients with acute inferior myocardial infarction. A higher ST segment elevation in lead III than in lead II and deeper ST segment depression in AVL are highly sensitive and specific markers for right coronary artery related acute inferior wall myocardial infarction.

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