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To Study the Accuracy of ECG in Localizing the Site of Occlusion in Acute STEMI and its Angiographic Correlation.

Ashish Shankhdhar[1] , Shridhar Dwivedi[2] , Vinod Sharma[3] , Dr. Munir Ahmad Khan[4]

Corresponding author and contact details:
Dr. Munir Ahmad Khan, Assistant Professor, Department of Anesthesia, MGM Superspecialty Hospital, MGM Medical College, Indore

drmunir82@gmail.com

Abstract

Background:

This study has been designed to localize the site of occlusion in acute STEMI (ST elevation MI) , by ECG findings according to the various algorithm and to correlate it with coronary angiographic findings and fill gaps in the literature from the Indian population.

Methods:

Patients of STEMI presenting within 12hours from the onset of symptoms were included in this study. Relevant clinical and biochemical laboratory parameters such as lipid profile, cardiac markers were obtained from the patients. Coronary angiography was performed to detect the culprit lesion as significant stenosis (>70%) in the coronary artery. The aim is to study the electrocardiographic profile of the patients and relate it with angiography findings.

Results:

160 patients who fulfilled the inclusion criteria were enrolled in the study. The main culprit artery was found to be LAD (Left anterior descending) 89 (55.6%), followed by RCA (right coronary artery)53 (33.1%) and LCx (Left circumflex) 18 (11.3%). The angiography findings showed dominant circulation as RCA 135 (84.4%) and LCx 15 (9.4%). The angiography revealed four patients had no lesion while lesions in LAD were observed in 85 (53.1%) patients, RCA in 52 (32.5%), and LCx in 19 (11.9%). The ECG findings using FIOL's algorithm for LAD occlusion site proximal to D1 (diagonal) showed 70.31% sensitivity, 88% specificity, positive predictive value 93.75%, and negative predictive value 53.66%. . The sensitivity,

[1] MD, DrNB Cardiology, Assistant Professor, Department of Cardiology, BMHRC, Bhopal -462038, India

[2] Professor, Department of Cardiology, National Heart Institute, New Delhi -110065, India

[3] Senior Cardiologist and Head of Department of Cardiology, National Heart Institute, New Delhi -110065, India

[4] Assistant Professor, Department of Anesthesia, MGM Superspecialty Hospital, MGM Medical College, Indore

specificity, PPV (positive predictive value) and NPV (negative predictive value) of ECG based findings for culprit artery against coronary angiography using various algorithm showed 100% sensitivity, 94.67% specificity, 95.51% PPV and 100% NPV for LAD, 94.23% sensitivity, 96.30% specificity, 92.45% PPV and 97.20% NPV for RCA, and 89.47% sensitivity, 98.58% specificity, 89.47% PPV and 98.58% NPV for LCx.

Conclusion:
There is a good correlation between ECG changes in the acute phase of MI with ST elevation and the affected myocardial zone and the location of the occluded artery. The careful ECG analyses can help in making a decision to recommend an urgent PTCA (percutaneous transluminal coronary angioplasty).

Keywords: STEMI, Coronary artery, Electrocardiography, angiographic profile, Fiol's algorithm

1. INTRODUCTION

The myocardium is usually supplied by three coronary arteries, although there are several variations in the number, origin, course, and distribution of coronary arteries. The major contribution to left ventricular myocardial blood flow is by left anterior descending coronary artery (LAD) (50%), rest is equally contributed by right coronary artery (RCA) and left circumflex artery (LCx). Also, most of the right ventricle is supplied by RCA.[1]

The changes of ST, elevations, and depressions, not only recognize which walls are affected in course of AMI but also the place of occlusion and the anatomical characteristics of the occluded culprit coronary artery responsible for AMI. ST elevation is found in the leads that face the head of the injury vector, and that in the leads opposite ST depression may be recorded as a mirror image because these leads face the tail of this vector.[2]

Various electrocardiographical criteria have been described, based on these ST changes, to determine precisely the place of occlusion in a culprit artery.[34,5,6,7,8,9,10,11,12]

The important features favoring the right coronary artery rather than the LCx artery as the culprit artery in IWMI are ST-segment elevation in lead III> lead II and more than 1 mm ST-segment depression in leads I and aVL.[13,14] In IWMI caused by RCA occlusion, the injury vector is directed towards the right (lead III), hence ST-segment elevation in lead III is greater than that in lead II.[15] One of the important clues that suggest proximal occlusion of the right coronary artery with associated right ventricular infarction in a case of IWMI is the additional finding of ST-segment elevation in lead V1.[3] Conversely, IWMI due to LCx occlusion produces an ST-segment vector directed toward the left (lead II). In this case, ST-segment elevation in lead III is not greater than that in lead II, and there is an isoelectric or elevated ST segment in lead aVL.[16,17] Associated ST-segment depression in leads V1 and V2 in a case of IWMI suggests concomitant posterior wall MI, which is usually caused by LCx occlusion but may also be seen in dominant RCA occlusion.[18] Lead V4R helps differentiate proximal versus distal RCA occlusion versus LCx occlusion

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by noting the presence or absence of convex upward ST-segment elevation in V4R and by identifying whether the T wave is positive or negative inV4R.[19]

Patients who presented with ECG criteria of proximal occlusion (any ST-depression in III+aVF>0.5 plus the sum of ST-deviation in aVR+V1–V6≥0) constitute a high-risk group.[20] This high-risk group had a lower ejection fraction, the higher peak of creatinine phosphokinase (CPK) and its isoenzyme MB (CPK-MB), and worse Killip class, and included more patients with major adverse cardiac events compared to the patients who did not meet all these criteria.

The importance of knowing the culprit artery responsible for STEMI before putting the patient to invasive coronary angiography will help in categorizing the patients who are at higher risk of considerable damage to the myocardium.

2. Methods

2.1 Study Design and participants

This prospective, cross-sectional analytical study was conducted in a tertiary care hospital after approval from the Institute’s ethical committee from June 2018 to May 2019. 160 patients of both sexes were enrolled after written informed consent in 12months duration who presented to the institute within 12hours of onset of chest pain, shortness of breath, palpitation, sweating. Acute STEMI was diagnosed with the above symptoms along with ECG changes (new ST elevation at J point ≥0.2mv in males and ≥0.15mv in females in lead V2, V3, and ≥0.1mv in other leads) and/or raised cardiac biomarkers Troponin T/I, CK-MB, CPK).In this study we focused on Fiol's algorithm20 (Figure 4) for LAD and some other pre- specified criteria (figure 1,2,3) for prediction of RCA and LCX . CAG results were compared with those predicted by ECG. Patients of NSTEMI, previous MI/bypass/graft/PCI/congenital heart disease/bundle branch block/pacemaker, and patients not willing for coronary angiogram were excluded from the study.

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Figure 1

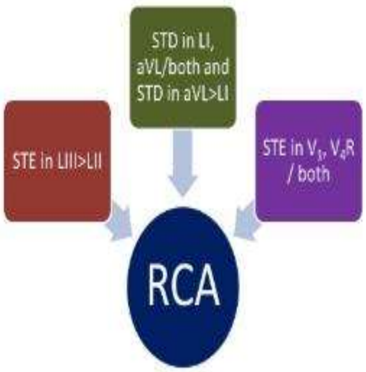

Fig. 1: Electrocardiographic predictors of right coronary artery occlusion in inferior wall myocardial infarction (IWMI)

Figure 2

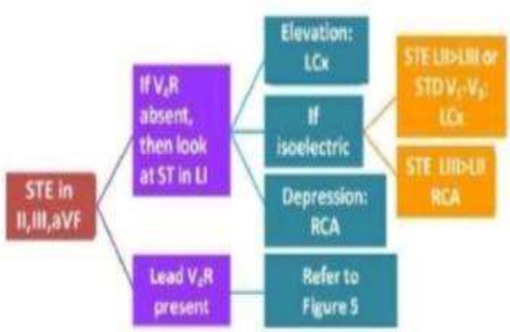

Fig. 2: Algorithm for predicting infarct related artery in inferior wall myocardial infarction

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Figure 3

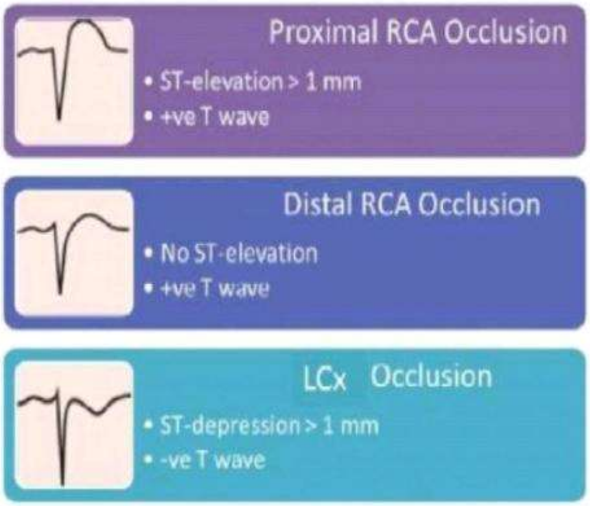

Fig. 3: ST-T changes in lead V₄R to predict infarct related artery

Figure 4

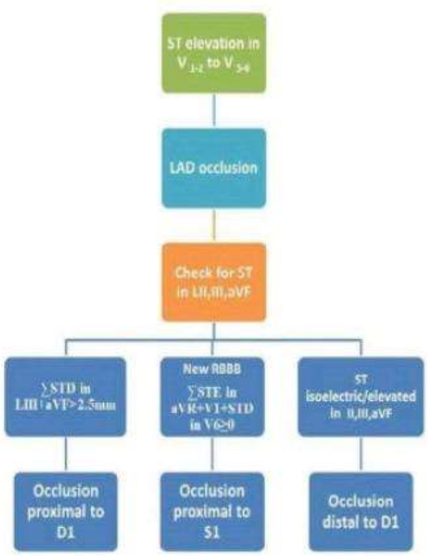

Fig. 4: Algorithm to precisely locate the site of left anterior descending coronary artery occlusion in the case of evolving myocardial infarction with ST elevation in precordial leads

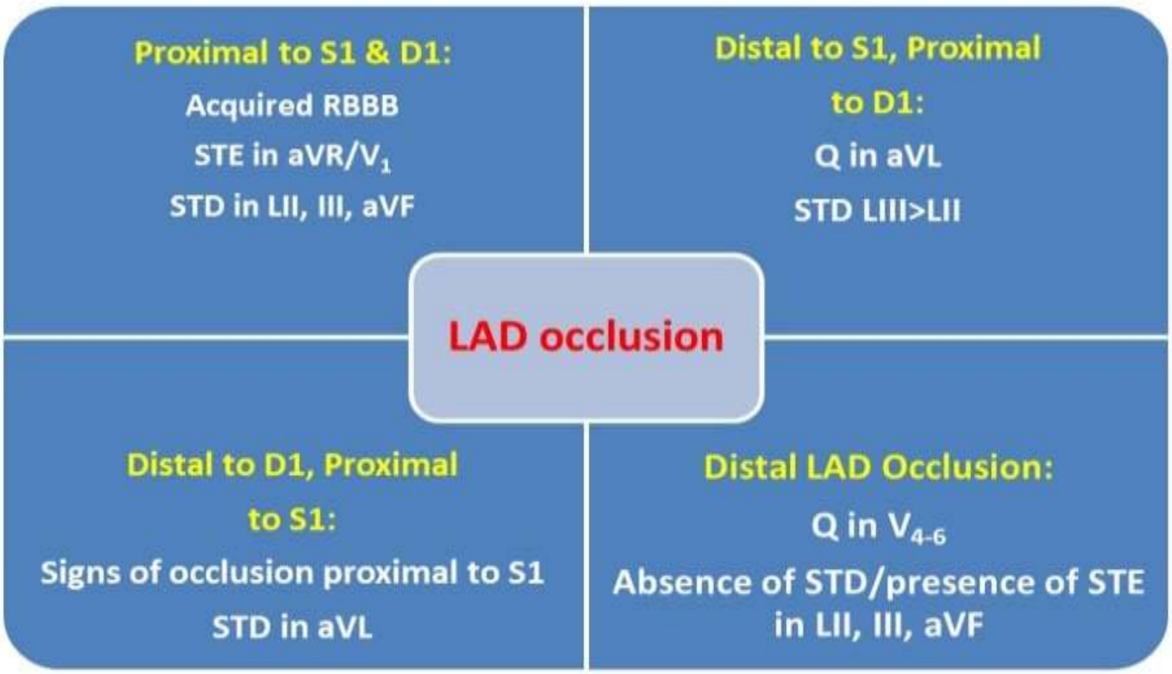

Figure 5: Electrocardiographic predictors of location of occlusion in LAD in anterior myocardial infarction

2.2 Data collection

Demographic details, thorough physical examination, and a detailed personal and family history were obtained from the patients. The relevant set of biochemical laboratory investigations as lipid profile, cardiac biomarkers, thyroid profile, and blood sugars were sent. Meanwhile, ECG and coronary angiography were performed to detect the culprit lesion. Significant lesion/stenosis was defined by the presence of >70% stenosis/thrombosis or dissected plaque in the coronary artery.

2.3 Statistical Analysis

The data was recorded in the excel sheet. The descriptive data were analyzed using SPSS software version 20. The categorical data were presented as numbers and percentages and continuous data as mean and standard deviation (SD). The sensitivity, specificity, PPV, NPV, accuracy was calculated using Med calc software.

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3. Results

The mean age of the study population was 60.3±13.7years and the frequency of male patients was 76.9% as compared to 23.1% female patients shown in Table 1). The most common co-morbidity found in the study population was hypertension (58.1%) followed by diabetes (32.5%) and CVA (cerebro vascular accident) (11.2%).

Tables

Table 1

Demographics	Male	Female	Number (n=160)	Percentage (%)
Age group (years)				
21-40	12	1	13	8.1
41-60	58	10	68	42.5
61-80	48	22	70	43.8
>80	5	4	9	5.6
Age (years)			60.3 (mean)	13.7 (SD)
		Sex		
Male			123	76.9
Female			37	23.1

Data presented as mean (Standard deviation) or n.(number)

Then cardiac biomarkers were tested for all the patients and the findings are shown in table 2 with troponin t positive in 99.4% of the patients.

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Table 2

Biomarkers	Mean	SD
CPK (U/ L)	559	352
CKMB (IU/L	94.58	60.5
Trop-t (qualitative)	n=160	Percentage
Positive	159	99.4
Negative	1	0.6

Data presented as mean (Standard deviation) or n.

The FIOL'S algorithm was followed to describe the culprit artery and the location of the lesion using ECG findings. The main culprit artery was found to be LAD 89 (55.6%), followed by RCA 53 (33.1%) and LCx 18 (11.3%). The location of lesion distal or proximal in RCA and distal, proximal, between D1 & S1 (septal) or between S1 & D1 in LAD and LCx involvement, according to ECG findings following various algorithm as shown in figures 1-4.

The angiography findings showed dominant circulation as RCA 135 (84.4%) and LCx 15 (9.4%). The angiography revealed four patients had no lesion while lesions in LAD were observed in 85 (53.1%) patients, RCA in 52 (32.5%), and LCx in 19 (11.9%).

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ECG findings based on FIOL's algorithm were tested against the gold standard angiography findings. The occlusion site proximal to D1 showed 70.31% sensitivity, 88% specificity, positive predictive value 93.75%, and negative predictive value 53.66%, while other occlusion sites showed either high sensitivity or specificity only.

The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of ECG based findings for culprit artery showed 100% sensitivity, 94.67% specificity, 95.51% PPV and 100% NPV for LAD, 94.23% sensitivity, 96.30% specificity, 92.45% PPV and 97.20% negative NPV for RCA, and 89.47% sensitivity, 98.58% specificity, 89.47% PPV and 98.58% NPV for LCx.

4. Discussion

The results of our study show LAD (55.6%) was the main culprit artery followed by RCA (33.1%) and LCx (11.3%) from the ECG findings which are similar to Chakraborty et al., 2017[21] who reported LAD (73%) as main culprit artery followed by RCA (24%) and LCx (3%). Ghosh et al., 2013[22] also reported the main culprit as LAD (52.38%) followed by RCA (47.62%), and no case was reported with LCx. However, Hoh et al., 2019[23] reported the main culprit artery as RCA (55.3%), followed by LAD (40.2%) and LCx (4.5%).

Correlation between ECG findings based on FIOL's Algorithm and angiography findings for LAD as shown in figure 6

ECG criteria ΣST depression III+aVF ≥ 2.5mm used to identify the occlusion site proximal to D1:In the present study, the sensitivity, specificity, PPV, and NPV were found to be 70.31%, 55%, 93.75%, and 53.66% respectively. However, Chakraborty et al. 2019[22], and Hoh et al., 2017[23] reported lower sensitivity (29%& 16.67%, respectively), PPV (83%), NPV (33%), and higher specificity (86%& 100%, respectively) than the present study. The present study finding was similar to that of Fiol's study[20], which reported sensitivity (77%), specificity (84%), PPV (92%), and NPV (61%).

ECG criteria ST-segment in III and aVF isoelectric or elevated used to identify occlusion site distal to D1: In the present study, the sensitivity, specificity, PPV, and NPV were found to be 27.27%, 79.1%, 30%, and 76.81% respectively. Chakraborty et al. 2019[22], and Hoh et al., 2017[23] reported higher sensitivity (62% & 96%, respectively), PPV (45%), NPV (82%) and lower specificity (69% & 66.67%, respectively) than the present study. The present study finding was similar to that of Fiol's study20, which reported sensitivity (44%), specificity (100%), PPV (100%), and NPV (70%).

ECG criteria Sum of aVR+V1-V6 ≥ 0used to identify occlusion site proximal to S1: In the present study, the sensitivity, specificity, PPV, and NPV were found to be 95.74%, 16.67%, 56.25%, and 77.78% respectively. Chakraborty et al. 2019, reported similar sensitivity (90%), specificity (33%), PPV (61.5%).

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ECG criteria Sum of aVR+V1-V6 < 0 used to identify occlusion site distal to S1: In the present study, the sensitivity, specificity, PPV and NPV was found to be 16.57%, 95.74%, 77.78% and 56.25% respectively. Chakraborty et al. 2019[22] and Fiol et al., 2009[20] reported similar findings low sensitivity (33% & 44%, respectively), and high specificity (90% & 100%, respectively), PPV (61.5% & 100, respectively), and NPV (73% & 46%, respectively).

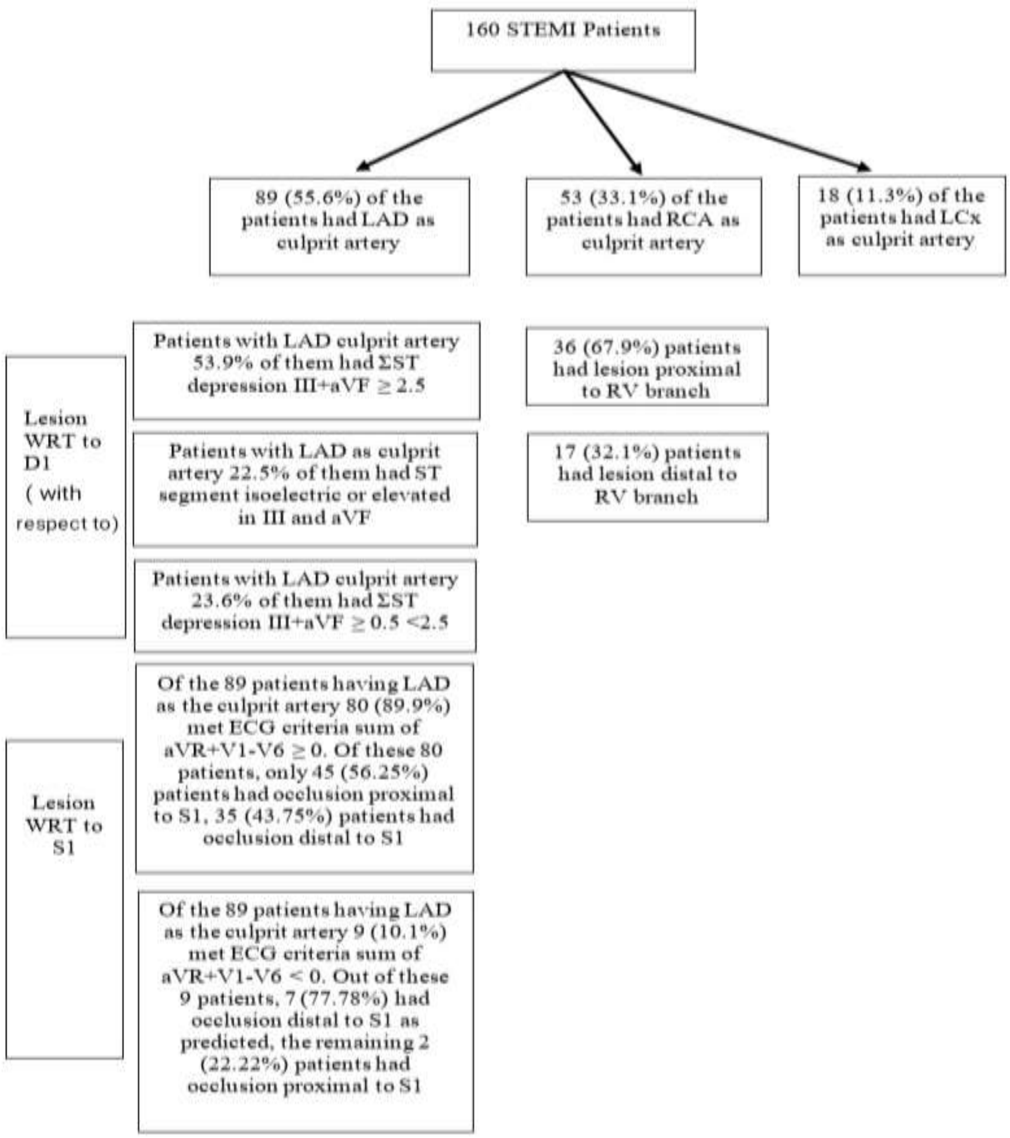

Figure 6: Summary of angiographic finding as per ECG criteria

Comparison of angiographic findings based on ECG criteria

The sensitivity, specificity, PPV and NPV of ECG findings for culprit artery showed 100% sensitivity, 94.67% specificity, 95.51% PPV and 100% NPV for LAD, 94.23% sensitivity, 96.30% specificity, 92.45% PPV and 97.20% negative NPV for RCA, and 89.47% sensitivity, 98.58% specificity, 89.47% PPV and 98.58% NPV for LCx. Chakraborty et al., 2019[22] showed the higher sensitivity (100%) and lower specificity (33.33%), PPV (92.3%) and NPV (100%) for RCA and .lower sensitivity (33.3%) and higher specificity (100%), PPV (100%) and NPV (92.3%). However, Ghosh et al., 2013[21] using diagnostic criteria of ECG for the location of occlusion reported the sensitivity of ECG criteria was maximum for groups Ib+c(distal to S1 irrespective of D1) and IIb (RCA distal to RV) 100% followed by group IIa (RCA proximal to RV) 71.43%, group Ic (distal to both S1 and D1) 50%, group Ia(proximal to both D1 and S1) 42.86% and least for Group Ib(distal to S1 but proximal to D1) (0%). The specificity was maximum for Groups Ia and IIa (92.86%) followed by Group Ib (90%), Group IIb (89.47%), Group Ic (78.95%), and Group Ib+c (77.78%) in that order. The PPA and NPA for Groups Ia, Ib, Ic, Ib+c, IIa and IIb were 75% and 76.47%, 0% and 94.74%, 20% and 93.75%, 42.86% and 100%, 83.33% and 86.67% and 50% and 100%, respectively.

Although coronary angiography is the gold standard for determining the infarct-related artery in acute myocardial infarction, the ECG can be a clinically valuable tool in identifying the culprit artery. [24]Accurate localization of infarct-related artery from surface electrocardiogram is crucial in the formulation of management and the need for early thrombolysis or primary percutaneous coronary intervention.

The amount of left ventricle mass that presents hypoperfusion and is at risk of evolving to MI in the course of LAD STEMI depends greatly on the location of the LAD occlusion.[20] The findings of Masoudi et al. 2006 suggest that the failure to identify high-risk ECG patterns in patients with acute myocardial infarction (AMI) results in lower quality care in the emergency room and highlights the importance of system changes to enhance the accuracy of ECG interpretation.[25]

Occlusion of the LAD artery may lead to a very extensive anterior MI, or only septal, apical-anterior, or mid-anterior according to the site of occlusion. Proximal LAD occlusion has been documented as an independent predictor of poor outcome related to higher mortality and recurrent MI and distal LAD occlusion is considered to have a better outcome.[5, 26] Ischemia provoked by LAD occlusion is reflected by ST- elevation in precordial leads. The different ECG criteria for predicting the site of occlusion are based on the direction of the injury vector. Using Fiol’s algorithm, as an approach to identify and ascertain the culprit artery in STEMI provides either high sensitivity or high specificity, and accuracy was low to moderate (58.43-75.28%). Different criteria used to differentiate between proximal and distal LAD, proximal and distal RCA and LCx using the deviation of ST leads appeared as the most useful standard. In the present study, the location of occlusion in LAD showed 97.5% accuracy, RCA showed 95.62% accuracy and LCx showed 97.5% accuracy among the STEMI patients.

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The limitations of this study were that the onset of symptom and presentation of the patient to the hospital was variable thus causing variation in the ECG.

Conclusion

There is a good correlation between ECG changes in the acute phase of a MI with ST elevation and the affected myocardial zone and the location of the occluded artery. Looking at the ECG leads that present the most prominent ST elevation and checking the reciprocal changes in other leads (ST elevations and depressions) can help to predict with relatively high sensitivity and specificity which is the culprit artery, and the location of the coronary occlusion. The careful ECG analyses can help in making a decision to recommend an urgent PTCA.

Conflict of interest: all authors have no conflict of interest.

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Main Points

This is an institution-based prospective observational study conducted during the period of June 2018 to May 2019 with a sample size of 160.

All STEMI patients underwent relevant biochemical investigations (Cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, blood sugar level, Troponin-t, CK-MB, CPK, TSH), ECG, and coronary angiography.

The main culprit artery was found to be LAD 89 (55.6%), followed by RCA 53 (33.1%) and LCx 18 (11.3%).

The ECG findings using FIOL's algorithm for LAD occlusion site proximal to D1 showed 70.31% sensitivity, 88% specificity, positive predictive value 93.75%, and negative predictive value 53.66%. Other sites showed either higher sensitivity or higher specificity.

The sensitivity, specificity, PPV and NPV of ECG based findings for culprit artery against coronary angiography showed 100% sensitivity, 94.67% specificity, 95.51% PPV and 100% NPV for LAD, 94.23% sensitivity, 96.30% specificity, 92.45% PPV and 97.20% NPV for RCA, and 89.47% sensitivity, 98.58% specificity, 89.47% PPV and 98.58% NPV for LCx.

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