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Use of Electrocardiography in Identification of Culprit Vessel and Localising the Lesion in Acute Myocardial Infarction with Angiographic Correlation

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Methods: This was a single-center, prospective study conducted at a tertiary-care center in India. A total of 100 patients diagnosed with AMI who underwent coronary angiography between November 2014 and October 2015 were included in the study. Patients diagnosed with AMI were evaluated, and the ECG findings of each patient were correlated with that of coronary angiogram to localize the culprit vessel involved.

Results: A total of 100 patients diagnosed with AMI with a mean age of 55 years were included in the study. Of these, the majority of the patients were male (91%). Out of 100 AMI patients, left anterior descending artery (LAD) was found to be the most common culprit artery [70 (70%) patients] followed by right coronary artery (RCA) [25 (25%) patients] and left circumflex (LCX) artery [5 (5%) patients], respectively. Among this 70% of patients who had LAD as a culprit artery, 10% of patients had additional insignificant lesions in LCX and 5% patients in RCA.

Keywords: acute myocardial infarction; electrocar- diogram; ST-segment elevation.

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Conclusion: This study concluded that ECG can reliably predict the culprit artery in AMI patients and can be used in identifying the level of occlusion in the artery. Particularly in hospitals without angiographic facilities, simple 12 lead ECG could become pivotal in guiding management decisions.

Keywords: acute myocardial infarction; electrocardiogram; ST-segment elevation.

I. Introduction

We are in the middle of a true global cardiovascular disease outbreak. Coronary artery disease (CAD) is one of the most important public health problems in India and worldwide. The prevalence of CAD in India has been increasing steadily with prevalence varying from 1-2% in the rural population and 2-4% in the urban population (1). About, 80% of deaths occur in developing countries and 30% of all deaths worldwide each year due to CAD (2). The 30-day mortality rate from acute myocardial infarction (AMI) is 30% with more than half of these deaths occurring before the affected individual reaches the hospital (3). Approximately, one of every 25 patients who survive the initial hospitalization dies in the first year after AMI (4). Mortality is about four-fold higher in elderly patients (over age 75 years) compared with younger patients (3).

Myocardial infarction (MI) is one of the most common presentation of CAD requiring immediate diagnosis and management in emergency settings. Acute risk stratification in AMI is based on laboratory parameters and 12-lead electrocardiogram (ECG). The 12-lead ECG has been a preliminary screening and one of the most useful diagnostic investigations in AMI (5). The early and accurate identification of the culprit artery in the setting of ST-elevation myocardial infarction (STEMI) is important because of the prognoses and the potential complications associated with a particular artery regarding the urgency of revascularization (6). ECG is a chief marker of microvascular blood flow and consequent prognosis. ECG reflects the electrophysiology of myocardium during acute ischemia whereas the coronary angiography shows the vessel anatomy (7). Since ECG has prognostic implications, several ECG criteria have been developed to identify the culprit artery in MI. Thus, this study has been undertaken to evaluate the use of ECG in identifying the culprit artery and correlating these ECG changes with coronary angiography for localizing the lesion in acute MI patients.

II. Methods

a) *Study design and patient population*

This was a single-center, prospective study conducted at a tertiary-care center in India. A total of 100 patients diagnosed with AMI who underwent coronary angiography between November 2014 and October 2015 were included in the study. Patients diagnosed with AMI were evaluated, and ECG findings of each patient were correlated with that of coronary angiogram to localize the culprit vessel involved. The AMI patients with chest pain lasting 30 minutes, ECG criteria of ST-segment elevation >1mm in at least two contiguous leads in limb leads and >2mm in chest

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leads and those who underwent coronary angiogram subsequently were included in the study. Patients with the history of previous MI, prior coronary artery bypass graft (CABG), congenital heart disease, ECG showing features of left ventricular hypertrophy (LVH), left bundle branch block in baseline ECG and patients with non-ST-elevation myocardial infarction (NSTEMI) were excluded from the study. Signed informed consent was obtained from all the patients before the investigations.

b) Electrocardiography evaluation

In 2006, Hein J. J. Wellens et al. (8) summarized the ECG criteria for identification of the culprit artery in myocardial infarction as follows:

A. Anterior ST-elevation (leads V1-2 to V4-5) suggests left anterior descending artery occlusion.
B. Inferior ST-elevation (leads II, III, aVF) suggests occlusion of either right coronary artery (RCA) or left circumflex artery (LCX). In the patients with inferior ST-elevation, ST-elevation in II>III is suggestive of occlusion of LCX and ST-elevation in III>II is suggestive of occlusion of RCA.
C. If ST-elevation is there in leads aVR and aVL along with ST-depression in the lead II, III and aVF indicates occlusion is proximal to first septal and first diagonal branch.
D. If ST-elevation is in leads I and aVL along with ST-depression in the lead III and ST-elevation in leads V2 to V6 indicates occlusion is distal to the first septal branch but proximal to the first diagonal branch.
E. If there is ST-depression in lead aVL and ST-elevation in inferior leads with highest in lead III along with ST-elevation in leads V1 to V4 indicates occlusion distal to the first diagonal branch and proximal to the first septal branch.
F. If there is ST-depression in aVR along with ST-elevation in inferior leads with highest in lead II and ST-elevation in leads V3 to V6 indicates occlusion of distal LAD.
G. ST-elevation in lead V4R with positive T-wave suggests RCA occlusion proximal to right ventricle (RV) branch, whereas isoelectric or isoelectric ST-segment in V4R suggests RCA occlusion distal to RV branch.

These set of criteria was applied to all the patients included in the study to identify the culprit vessel and the level of occlusion in the vessel involved by ECG obtained at the time of presentation. Later, these patients underwent coronary angiography at our hospital. The results obtained after applying the ECG criteria were compared with the results obtained from coronary angiography.

c) Statistical analysis

The data obtained was analyzed, and the results were presented in the form of numbers and percentages. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of individual parameters were calculated to study the efficiency of ECG criteria applied for identifying the culprit's vessel.

III. Results

A total of 100 patients diagnosed with AMI with a mean age of 55 years were included in the study. Of these, the majority of the patients were male (91%). The LAD artery was found to be the most common culprit artery [70 (70%) patients] followed by RCA [25 (25%) patients] and LCX artery [5 (5%) patients], respectively. Among this 70% of patients who had LAD as a culprit artery, 10% of patients had additional insignificant lesions in the LCX and 5% of patients in RCA. Of this 25% of patients who had RCA as a culprit artery, 6% of patients had additional lesions in LAD and 2% of patients in the LCX artery. These lesions caused an insignificant obstruction. Baseline demographics, sites of occlusions in LAD and RCA of the study population, were displayed in Table 1.

Table 1: Baseline demographics, site of occlusions in LAD and RCA of the study population

Characteristics	Patients (N=100)
Age (mean, years)	55
Male, n (%)	91 (91%)
Culprit artery	
LAD, n (%)	70 (70%)
RCA, n (%)	25 (25%)
LCX, n (%)	5 (5%)
Occlusion in LAD	
Proximal to S1 and D1, n (%)	8 (11.4%)
Proximal to D1 but distal to S1, n (%)	50 (71.4%)
Distal to D1 but proximal to S1, n (%)	7 (10%)
Distal to S1 and D1, n (%)	5 (7.2%)
Occlusion in RCA	
Proximal RCA, n (%)	15 (60%)
Distal RCA, n (%)	10 (40%)

LAD: left anterior descending; RCA: right coronary artery; LCX: left circumflex artery

Table 2: Comparison of various ECG criteria used in predicting the levels of occlusion

Variables	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Occlusion in LAD				
Occlusion distal to S1 but proximal to D1	95	5	90	70
Occlusion proximal to S1 but distal to D1	50	95	70	90
Occlusion in proximal LAD	85	67	75	80
Occlusion in distal LAD	67	85	80	75
Occlusion in RCA				
Proximal RCA	83	61	80	66
Distal RCA	61	83	66	80

LAD: left anterior descending; RCA: right coronary artery.

a) Distribution of occlusion in LAD artery

In this study, ECG criteria were applied to all the patients to identify the culprit vessel with 100% sensitivity and specificity. Out of 70 patients who had occlusion in LAD artery, 50 (71.4%) patients had occlusion proximal to D1 but distal to S1, eight (11.4%) patients had occlusion proximal to both S1 and D1, seven (10%) patients had occlusion distal to D1 but proximal to S1 and five (7.2%) patients had occlusion distal to both S1 and D1, respectively. Out of 50 patients having occlusion proximal to D1 but distal to S1, 45 (90%) patients were found to have lesion distal to S1 and proximal to D1, and five (10%) patients were found to have lesion distal to D1 and proximal to S1. Of the eight patients having proximal LAD involvement, merely six (75%) and two (25%) patients were found to have proximal and distal LAD involvement, respectively. Among the seven patients identified as having lesion distal to D1 and proximal to S1 were alienated as: five patients had lesions at the same site and two patients had lesion distal to S1 and proximal to D1. Of the five patients having distal LAD involvement, one and four patients were found to have proximal and distal LAD involvement on angiography. In cases of LAD occlusions distal to S1 but proximal to D1 the ECG had good sensitivity (95%) but moderate specificity (50%). For occlusions proximal to S1 and distal to D1 the sensitivity was moderate (50%) but specificity was high (95%). For proximal LAD occlusions the sensitivity was found to be high (85%) while the specificity was found to be moderate (67%), and for distal LAD occlusions ECG had moderate sensitivity (67%) but high specificity (85%). The sensitivity, specificity, PPV and NPV values for the ECG criteria applied to identify the level of occlusion in LAD in the study population were shown in Table 2.

b) Distribution of occlusion in RCA artery

Out of 25 patients having RCA occlusion, 15 (60%) patients had proximal RCA occlusion, and 10 (40%) patients had distal RCA occlusion. Of these 15 patients who had proximal RCA involvement, merely ten and five patients found to have proximal and distal RCA occlusion, respectively. Among the ten patients identified as having distal RCA involvement, eight and two patients were found to have distal and proximal RCA involvement, respectively. In case of RCA proximal occlusions ECG had good sensitivity (83%) but moderate specificity (61%), and in case of RCA distal occlusions, ECG had good specificity (83%) but moderate sensitivity (61%). The sensitivity, specificity, PPV and NPV values for the ECG criteria applied to identify the level of occlusion in RCA in the study population were shown in Table 2.

IV. Discussion

Though coronary angiography is the gold standard for determining the infarct-related artery (IRA) in AMI, the ECG can be a clinically valuable tool in identifying the culprit artery (9). In the current study, various ECG criteria was used for the diagnosis of IRA in AMI with angiographic findings. In the previous study (10) it was reported that the mean age of CAD patients in India was 49 years and also proved that the prevalence of CAD increases with age. In this study, the mean age of the study population was 55 years which is consistent with a study by Yusuf S et al. (11). The mean age of patients was 58.6 years in the CREATE-ECLA (12) randomized controlled trial which is comparable to this study results. Age and sex are the most powerful independent risk factors for CAD. Among the study population, the majority of the population were males (91%) which is similar to a study by Markandeya G.K.M et al. (6). A study in Washington State (13) concluded that CAD is an equal opportunity killer in men and women over their lifetimes which is in contrast to the current study showing that incidence of CAD was about four times high in male than that of the female.

Accurate localization of IRA from surface ECG is crucial in the formulation of management and need for early primary percutaneous coronary intervention (PCI). The recent findings of Masoudi et al. (14) suggest that failure to identify high-risk ECG patterns in AMI patient's results in lower quality care in emergency and highlights the importance of system changes to enhance the accuracy of ECG elucidation. Among the 100 patients included in the study, 70% of patients had anterior wall myocardial infarction (AWMI), and 30% of patients had IWMI which is similar to a study by Markandeya G.K.M et al. (6) and Chakraborty S et al. (15). In AMI patients, Hein J.J. Wellens et al. (8) ECG criteria have been used to identify the culprit artery and site of the occlusion. In case of the site of occlusions in LAD artery, most of the results of this study were comparable to a study done by Engelen et al. (16) and Salunke KK et al. (3).

In 2006, application of ECG criteria was described by Hein J. J. Wellens et al. (8) Similarly, in the current study, these ECG criteria were able to identify the culprit artery in MI correctly with 100% sensitivity and specificity. In cases of LAD occlusions distal to S1 but proximal to D1 the ECG had good sensitivity (95%) but specificity (95%) was high for occlusions proximal to S1 and distal to D1, for proximal LAD occlusions the sensitivity was found to be high (85%) while the specificity was found to be high (85%) in distal LAD occlusions. These sensitivity and specificity results were comparable to a study conducted by Vasudevan et al. (5) and Engelen et al. (16). In case of RCA proximal occlusions ECG had good sensitivity (83%) but moderate specificity (61%), and in case of RCA distal occlusions, ECG had good specificity (83%) but moderate sensitivity (61%). The diagnostic accuracy of this ECG abnormality in this study was comparable to a study by Glancy et al. (17) who showed a sensitivity of 96% and specificity of 40% for RCA involvement.

Thus, ECG has been a useful tool in identifying the lesions in the coronary arteries at the time of presentation in the emergency department. Any health personnel involved in emergency care should have in-depth knowledge of assessing ECG in AMI. It is important for emergency physicians to identify a very proximal LAD occlusion in acute AWMI. If the infarct site is proximal to the LAD artery, a large portion of the left ventricle (LV) is at risk for infarction. Such high-risk patients may require urgent transfer to a cardiac catheterization laboratory for primary PCI. The ECG need to be recorded and is important to identify patients with RCA occlusion because hypotension in these patients is usually caused by inadequate filling of LV and by poorly contracting right ventricle. By reflecting the pathophysiology of the myocardium during AMI or acute ischemia, important information to determine and prognosis guide management can be derived from ECG.

V. Conclusion

This study concluded that ECG is a good predictor in detecting the culprit artery and can be used in identifying the level of occlusion in the artery. Although coronary angiography remains the benchmark method for determining the infarct-related artery in AMI, ECG information can help to expect culprit artery involved before angiography, particularly in hospitals without angiographic facilities. In such settings, a simple 12 lead ECG could become pivotal in guiding management decisions.

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