Original Article

A hospital-based prospective study on analysis of axis deviation in patients with first attck of anterior wall myocardial infarction

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Abstract

Background and Aim: Electrocardiography is a very important investigative procedure that can be performed easily and quickly. A baseline investigation in the evaluation of cardiac status, one practical application of electrocardiogram, is axis determination, which is very useful in diagnosis and prognostication in patients with acute coronary syndromes. Therefore, the aim of this study is to calculate the mean QRS axis using the hexaxial reference frame in patients with the first acute myocardial infarction (MI) and to see if any relation exists between the axis deviation and the clinical outcome.

Methods: It is a hospital-based cross-sectional study conducted in 200 patients with the first attack of anterior wall MI with respect to a control group consisting 162 normal subjects. The mean frontal plane QRS axis was found using the hexaxial reference frame. Student's *t*-test and Pearson Chi-square test were used for statistical analysis of data.

Results: Twenty-five percent of the study subjects had left axis deviation, and 3.5% had right axis deviation. About 15% of the subjects developed left ventricular failure (LVF), of whom 19 (63%) were males and 11 (37%) were females. This difference between males and females was found to be statistically significant. The frequency of occurrence of LVF in females >61 years of age and that of arrhythmias in females 41–50 years was significantly higher.

Conclusion: The statistically significant difference between the mean electrical axis (MEA) of the study subjects when compared with the controls is not unexpected as MI produces deviation of the MEA. There was a tendency for a greater axis shift (30°) in patients who developed LVF; however, this shift was not found to be statistically significant.

Key words: Arrhythmias, axis shift, first myocardial infarction, left ventricular failure, mean electrical axis, mortality

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INTRODUCTION

Myocardial infarctions (MIs) are generally classified into ST elevation MI (STEMI) and non-STEMI.[1] An STEMI is the combination of symptoms related to poor oxygenation of the heart with elevation of the ST segments in the electrocardiogram (ECG).[2] They make up about 25–40% of the cases of acute coronary syndromes.[2] In the developed world, the risk of death in those who had an STEMI is about 10%.[3]

If impaired blood flow to the heart lasts long enough, it triggers a process called the ischemic cascade; the heart cells in the territory of the occluded coronary artery die (chiefly through necrosis) and do not grow back. A collagen scar forms in their place. Recent studies

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indicate that another form of cell death, apoptosis, also plays a role in the process of tissue damage following an MI.[4] It is estimated that one billion cardiac cells are lost in a typical MI.[5] This myocardial scarring also puts the person at risk for potentially life-threatening arrhythmias, and may result in the formation of a ventricular aneurysm. Thus, MI may cause heart failure, an irregular heartbeat, or cardiac arrest.[6,7] The current definitive treatment modalities for MI with ECG evidence of ST elevation (STEMI) include thrombolysis and percutaneous coronary intervention.[8] The ECG remains a crucial tool in the identification and management of acute MI. A detailed analysis of patterns of ST-segment elevation may influence decisions regarding the use of reperfusion therapy. The early and accurate identification of the infarct-related artery from the ECG can help to predict the amount of myocardium at risk.[9,10] Electrocardiographic signs of reperfusion represent an important marker of microvascular blood flow and consequent prognosis.[11,12] The ECG is also crucial for identifying new conduction abnormalities and arrhythmias that influence both short- and long-term outcome.[13] The specificity of the ECG in acute MI is limited by large individual variations in coronary anatomy as well as by the presence of pre-existing coronary artery disease. The ECG is also limited by its inadequate representation of the posterior, lateral, and apical walls of the left ventricle. Despite these limitations, the ECG can help in identifying proximal occlusion of the coronary arteries, which results in the most extensive and the most severe MI.

AV conduction abnormality is a major complication of STEMI. In anterior wall MI (AWMI), the infra-Hisian system (bundle branches and anterior and posterior fascicles) is affected, which usually indicates a large MI and adverse prognosis. There is proximal occlusion of the left anterior descending artery and septal necrosis. More commonly, necrosis of the septum is associated with slight PR prolongation (usually <0.25 s) due to involvement of the conducting system below the atrioventricular node. In this situation, PR prolongation is often associated with a wide QRS complex (>0.12 s) with a right bundle branch block pattern. Complete heart block results from extensive necrosis of the ventricular septum. It usually occurs abruptly during the first 24 h after MI and is almost always preceeded by the development of right bundle branch block with right or left axis deviation.[13] The mortality associated with complete heart block in anterior MI, with or without preceding right bundle branch block and left fascicular block, may be as high as 80%.[14] Determination of QRS axis is the definite method of diagnosing these types of conduction abnormalities.

The present study focuses on the patients who have a first MI and who deserve consideration as a special group. For the most part, the early mortality rate from a first infarction is roughly half the rate found in patients with a second or third infarction,[15,16] and the long-term survival is considerably better than in patients who have had previous infarctions.[17,18] The published studies on risk stratification[19-21] and treatment[22-24] after an infarction have paid remarkably little attention to patients having their first MI. Such patients constitute a majority (60–80%) of those with acute infarction.[25] There have been many proposals for objective standards in interpreting ECGs. So far, most of these recommendations are consensus based and are not derived from clinical trials that included patient outcomes.[26] Therefore, the present study was undertaken to correlate ECG with clinical outcome giving special attention to QRS axis deviation in patients presenting with the first attack of ST-elevated AWMI.

MATERIALS AND METHODS

Selection of subjects

A total of 200 cases (163 males and 37 females) were chosen according to the inclusion and exclusion criteria among acute MI patients admitted to the extensive coronary care unit in the Department of Cardiology, Medical College Hospital, Kottayam during the period from June 2004 to September 2005. A control group consisted of 162 (91 males and 71 females) subjects with no past or present cardiac illness.

Inclusion criteria

Patients of age 40 years and above with the first attack of acute anterior wall ST-elevated MI were included in the study. For a person to qualify as having an STEMI, in addition to clinical history and elevated cardiac biomarkers, the ECG must show new ST elevation in two or more adjacent ECG leads.[2] This must be greater than 2 mm (0.2 mV) in males and greater than 1.5 mm (0.15 mV) in females, if it is in leads V2 and V3, or greater than 1 mm (0.1 mV), if it is in other ECG leads.[2] In early STEMIs, there may just be peaked T waves with ST elevation developing later.[2]

Exclusion criteria

Patients with history of uncontrolled diabetes mellitus or systemic hypertension/patients with any other associated heart disease such as valvular heart disease or cardiomyopathy/patients with bundle branch blocks/patients admitted in Killip's Class IV/patients with preceeding angina/patients with any other systemic illness, which can modify the disease outcome were excluded from the study.

Selection of controls

Healthy individuals of both sexes in the age group of 40–80 years, who had no past or present history of cardiac illness or any other major illness, were selected as controls after getting their consent.

Brief procedure

A detailed history was taken, and physical examination was done with special emphasis on the examination of the cardiovascular system. ECG of the subjects was taken on three occasions,[25] the first ECG (ECG I) was taken at the time of admission and the second ECG (ECG II) was taken 90 min after thrombolysis or in patients without thrombolysis, ECG was taken on day 2. The third ECG (ECG III) was taken just before discharge or on day 3. The mean frontal plane QRS axis was calculated using the hexaxial reference frame and axis shift if any in the axes between the three ECG's were analyzed. The difference in electrical axis of the same subject when ECG is taken on different occasions has been called "axis shift." The axis shift calculated was categorized into 4 groups between ranges of 10° and 30° i.e., axis shift of ≤10°, between 10.0° and 20°, between 20.0° and 30°, and ≥30.0°. Axis shift between ECG's I and II was compared in 185 subjects and between I and III in 176 subjects. The in-hospital event rates and outcome were then assessed. Event rates refer to the primary end-points, i.e., complications such as left ventricular failure (LVF), major arrhythmias (tachyarrhythmia and bradyarrhythmias), and mortality, which were studied here.

The patient was laid comfortably on bed in the supine position and after proper earthing of the instrument; the electrode jelly was applied on the skin at the appropriate lead positions on the four limbs and the precordium. ECG's of the subjects studied were taken using Marquette 2000 portable electrocardiographs standardized at 25 mm/s and 10 mm/mV. The lead selector knob was adjusted so that the activity in different leads was recorded. The chest electrode was applied at different positions and the ECG in the leads V1 to V6 were recorded. Minimum three complexes were recorded in each lead and at least 10 complexes in lead II if an abnormal rhythm was suspected. Data were recorded, and application of the Student's *t*-test ensured the comparability of data. Association among variables was assessed using Pearson Chi-square test.

Calculation of the mean electrical axis

The mean electrical axis (MEA) was graphed using the hexaxial reference system.[27] The net voltages are plotted in leads I and III, and the MEA is calculated using these graphed values.[28] An error of 10–15° is not clinically significant.[29] A subject was considered left axis deviated if his/her axes were directed in the region between 0° counterclockwise and −90° and right axis deviated if the axes were directed to the region between +90° clockwise and +180°.[30]

RESULTS

Of 200, 57 (28.5%) study subjects had their MEA in either left or right axes compared to 20 (12.3%) of 162 controls, a difference that was statistically significant. The MEA in the I ECG was normal for 141 (71.5%), left axis deviated for 50 (25%), and right axis deviated for 7 (3.5%) of the study subjects as shown in Table 1. It was normal for 142 (87.7%), left axis deviated for 18 (11.1%), and right axis deviated for 2 (1.2%) of the control subjects. The *P* value of difference in values between the study and control subjects was found to be significant at <0.01.

Based on the complications developed such as LVF, major arrhythmias, and mortality, the subjects were further analyzed. Totally, 30 subjects (15%) developed LVF, of whom 19 were males and 11 were females. This difference between males and females was found to be statistically significant as shown in Table 2. None of the patients below 40 years of age developed any in-hospital complications, irrespective of their gender. Occurrence of LVF in female subjects ≥61 years of age was also found to be statistically significant (*P*: 0. 014) when compared to males and females in other age-groups. 18 patients (9%) developed major arrhythmias, of which 13 were males and 5 were females. Gender-based difference was not found to be statistically significant. However, 50% females in the age group 41–50 years developed major arrhythmias when compared to males and females in other age-groups, which was found to be statistically significant (*P:* 0.012). These facts are clear from Table 3. 190 subjects (95%) recovered and were discharged; the overall in-hospital mortality was 10 (5%). 154 (94%) male subjects and 36 (97%) female subjects were discharged. The mortality in males was 9 (6%) and 1 (3%) in females (*P*: 0.478).

The pre-discharge ECG could be obtained for only 178 subjects, of which 123 had normal MEA [Table 4]. On analysis of axis shift between ECG's I and II, 47% of the subjects had a minimal axis shift of ≤10° and 14% had a marked axis shift of ≥30.0°. However on comparison of axis shift during the whole period of hospitalization, i.e., between ECG's I and III, marked axis shift of ≥30.0° was seen in 22% of the subjects. Comparison of axis shift between the different ECGs in the study subjects is shown in Table 5. Axis shift was minimal (≤10°) among controls, and the maximum is 15°. Major axis shift of ≥30° was not recorded in any control subject.

Table 1: The axes of the subjects when the three ECGs were taken

	ECG I (*n*: 198) (%)	ECG II (*n*: 187) (%)	ECG III (*n*: 178) (%)
Normal	141 (70.1)	138 (69)	123 (61.5)
Left axis	50 (25)	40 (20)	39 (19.5)
Right axis	7 (3.5)	9 (4.5)	14 (7)
North-west region	-	-	2 (1)

ECGs: Electrocardiograms, ECG I: First ECG, ECG II: Second ECG, ECG III: Third ECG

Table 2: Frequency of complications in the study subjects

Complications	Total (*n*: 200) (%)	Males (*n*: 163) (%)	Females (*n*: 37) (%)	*P* value of male-female difference
LVF	30 (15)	19 (12)	11 (30)	0.005
Major arrhythmias	18 (9)	13 (8)	5 (14)	0.671

LVF: Left ventricular failure. Statistical analysis of data was done by Chi-square test. *P*>0.05 was considered significant

Table 3: Frequency of LVF and major arrhythmias in the study subjects

Complications	LVF (*n*: 30) (%)	*P* value of male-female difference	Major arrhythmias (*n*: 18) (%)	*P* value of male-female difference
41-50 years				
Males (*n*: 39)	5 (13)	0.446	3 (8)	0.012
Females (*n*: 4)	0 (0)		2 (50)	
51-60 years				
Males (*n*: 52)	9 (17)	0.184	5 (10)	0.800
Females (*n*: 8)	3 (38)		1 (13)	
≥61 years				
Males (*n*: 52)	5 (10)	0.014	5 (10)	0.817
Females (*n*: 25)	8 (32)		2 (8)	

LVF: Left ventricular failure. Statistical analysis of data was done by Chi-square test. *P*>0.05 was considered significant.

Table 4: The mean value of electrical axis among the subjects

Age	Mean axis of the study subjects	Mean axis of the control subjects
≤40 years	41.6°	54.5°
41-50 years	33.4°	45.7°
51-60 years	33.3°	43.7°
≥61 years	30°	38°

Table 5: Comparison of axis shift

Category	Between ECG's I and II (%)	*P* value (of difference in values)	Between ECG's III and I (%)	*P* value (of difference in values)
≤10°	94 (47)	0.696		0.75
10.01-20°	42 (21)		29 (14.5)	
20.01-30°	21 (10.5)		27 (13.5)	
≥30.01°	28 (14)		43 (21.5)	
	185		176	

ECGs: Electrocardiograms, ECG I: First ECG, ECG II: Second ECG, ECG III: Third ECG. Statistical analysis of data was done by Chi-square test. *P*>0.05 was considered significant

To assess the prognostic significance of axis shift among study subjects, the primary end-points, i.e., complications such as LVF, major arrhythmias, and mortality were studied during their whole period of hospital admission. All the three ECG's were available for 28 of 30 subjects with LVF, 17 of 18 subjects with arrhythmias, and 7 of 10 who died. Hence, only these subjects have been analyzed. Greater axis shift is noted among subjects with LVF and arrhythmias. To assess the predictability of a complication, subjects were classified into those with a complication and those without. Subsequently, tests of significance were applied and found to be nonsignificant as represented in Table 6. Of all the patients, 28.5% were put on thrombolytic therapy. Among the patients who died (10 in number), 3 were not put on thrombolytic therapy (2 patients had normal axis throughout the hospital stay while one went into left axis deviation of 10°). They, however, received angiotensin converting enzyme inhibitor and beta blocker drugs. The other 7 were put on thrombolytic therapy (3 patients had normal axis throughout the hospital stay while 2 went into left axis deviation >30° and 2 others had their axes swinging between normal and left axis).

DISCUSSION

In our study, ECGs taken on admission showed that 25% of the study subjects had left axis deviation, 7 (3.5%) showed right axis deviation, and the remaining showed normal axis. Prior studies revealed that left anterior hemiblock is the most frequent type of intraventricular conduction defect observed in the course of anterior MI.[31] Its frequent appearance is explained by the thin structure of this fascicle, which receives its blood supply from the anterior descending coronary artery and is often vulnerable to ischemic and necrotic insults.[32,33] Earlier studies show that right axis deviation due to left posterior hemiblock is by far the least frequent of all the intraventricular conduction defects during acute anterior MI.[34,35] Their infrequent appearance is explained by the double blood supply to the posterior fascicle of the left bundle branch.[36] A study by Sclarovsky *et al*.[37] on 11 subjects has shown that the average shift of the mean frontal axis to the right was 42° (i.e., ≥30.01°) and in 4 cases, there was only a slight shift of the electrical axis to the right (around 10°), but all patients had the pattern of left posterior hemiblock.

The prognostic significance of axis shift among study subjects was assessed with respect to the primary end-points, i.e., complications such as LVF, major arrhythmias, and mortality.[38] In our study, 30 subjects (15%) developed LVF post-MI and its occurrence in female AWMI subjects more than 61 years of age was found to be statistically significant ($P = 0.014$) compared to other age and gender categories. There is a tendency for a greater axis shift in patients who developed

Table 6: Comparison of axis shift with complications among the study subjects

Complication	Axis shift (in degrees) (%)		*P* value of difference in values
	≤10° (*n*: 68)	>10° (*n*: 108)	
LVF (*n*: 28)	7 (25)	21 (75)	0.106
Arrhythmia (*n*: 17)	7 (41)	10 (59)	0.821
Deaths (*n*: 7)	3 (43)	4 (57)	0.815

LVF: Left ventricular failure. Statistical analysis of data was done by Chi-square test. *P*>0.05 was considered significant.

LVF–A finding without any statistical significance. Arruda-Olson *et al*.[39] have shown that during a mean follow-up of 0.8 ± 0.7 years, 142 patients developed heart failure. Ventricular remodeling generally precedes the development of clinically evident congestive heart failure in months to years after infarction.[40]

Totally, 18 patients (9%) developed major arrhythmias. Occurrence of arrhythmias in female AWMI subjects in the age group 41–50 years was found to be significantly high (50%). The incidence of arrhythmias after MI is higher in patients seen early after the onset of symptoms. It is believed that although many patients have normal pulse rate and BP, within the 1st h of infarction, about 1/4th of the patients with anterior wall MI have manifestations of sympathetic nervous system hyperactivity (tachycardia and/or hypertension).[41] In a recent study by Rathod *et al*., the incidence of various arrhythmias was more common in AWMI and constituted 76% of all subjects studied. Tachyarrhythmias were seen commonly with AWMI while bradyarrhythmia occurred more often with inferior wall MI.[42] Our study revealed that 59% of the arrhythmic patients had an axis shift >10° and 41% had an axis shift ≤10°. The *P* value of difference in values was, however, nonsignificant at 0.821.

The third outcome we studied was mortality. Previous studies have shown a relation between the treatment delay and mortality outcome in MI patients.[43-46] Restoring blood flow promptly in an occluded coronary artery by either thrombolysis or angioplasty reduces mortality in MI with ST elevation.[47] With both treatments, the faster reperfusion achieved, the greater the reduction in mortality.[48,49] Guidelines from the European Society of Cardiology now state that primary angioplasty is the preferred therapeutic option when it can be performed "within 90 min after the first medical contact."[50] Among the subjects studied here, mortality was 57% for those with an axis shift >10° and 43% for those with an axis shift ≤10°. This relation is, however, nonsignificant with *P* = 0.815. Mortality can also be attributed to the delay in treatment. An analysis examining the impact of time delay in treatment showed a significant interaction between treatment effect and delay.[51] Large population-based studies have been done to investigate the effect of distance between home and acute hospital on mortality outcome of the patients experiencing an incident MI.[52-54] The risk factors between the populations and inadequacies in the level of medical care provided could presumably be one of the reasons that may explain the deaths here.

Limitations of the study

We could not go into depth on aspects of types of arrhythmias and mortality. Although the study was underpowered and a relation between postinfarction complications and axis shift cannot be excluded with certainty, the analysis is meaningful. A detailed study[52,55] involving a larger number of subjects could have provided better and newer insights on developing objective standards designed to optimize training, testing, and maintaining competency in interpretation of ECGs. However, resources and time were the limiting factors.

CONCLUSION

The statistically significant difference between the MEA of the study subjects when compared with the controls is predictable, as MI produces deviation of the MEA. There is a tendency for a greater axis shift in patients who developed LVF during illness, but this was not statistically significant. Occurrence of arrhythmias and deaths were also analyzed similarly, and their occurrences in certain age-groups of females were seen to be significant. The frequency of occurrence of arrhythmias in female AWMI subjects in the age group 41–50 years was significantly higher. However, a study on the axis shift during hospitalization was found to be statistically insignificant.

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Conflicts of interest

There are no conflicts of interest.

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