Section: General Medicine

Original Research Article

ELECTROCARDIOGRAPHIC AND ANGIOGRAPHIC CORRELATION IN LOCALIZING THE CULPRIT VESSEL IN ACUTE ST SEGMENT ELEVATION MYOCARDIAL INFARCTION IN PATIENTS ADMITTED TO TERTIARY CARE HOSPITAL.

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ABSTRACT

Background: Acute ST-segment elevation myocardial infarction (STEMI) is a major cause of morbidity and mortality. Electrocardiography (ECG) plays a pivotal role in identifying the culprit vessel, which is essential for timely intervention. This study aims to determine the correlation between ECG and coronary angiography (CAG) in localizing the culprit vessel in STEMI.
Materials and Methods: This observational study was conducted at a rural tertiary care hospital in India. A total of 107 patients diagnosed with STEMI were enrolled. Data were collected on demographic profiles, ECG findings, and CAG results. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of various ECG markers were compared to CAG findings, which served as the gold standard.
Results: Proximal LAD occlusion was the most common finding (42.1% of patients), followed by proximal RCA occlusion (15%). The ECG criteria for RCA occlusion (ST elevation in lead L3>L2) had a sensitivity of 92.31% and specificity of 91.36%. The specificity of ST elevation >1mm in lead V4R for diagnosing proximal RCA occlusion was 95.60%, with a PPV of 69.23%.
Conclusion: ECG provides a reliable, non-invasive method for predicting the location of the culprit vessel in STEMI. However, it must be used in conjunction with other diagnostic tools like CAG for accurate localization, especially in settings with limited access to angiography.
Keywords: STEMI, Electrocardiography, Coronary angiography.

INTRODUCTION

Heart disease and stroke are leading causes of death globally, accounting for 25%-30% of deaths due to cardiovascular disease (CVD). Acute myocardial infarction (AMI), particularly ST-segment elevation myocardial infarction (STEMI), is a major health concern, with high mortality rates, especially in the first year post-AMI. Early diagnosis and intervention are key to improving outcomes. While coronary angiography (CAG) is the gold standard for diagnosing coronary artery occlusion, it is often unavailable in developing regions.[1-3]

Electrocardiography (ECG), being widely accessible and non-invasive, plays a crucial role in diagnosing STEMI and initiating treatment, such as primary percutaneous coronary intervention (PCI).

This study aims to evaluate the diagnostic accuracy of ECG compared to CAG in localizing the culprit vessel in STEMI, focusing on the sensitivity, specificity, and predictive values of ECG parameters.

MATERIALS AND METHODS

An observational study was conducted in the Department of General Medicine at a super-specialty tertiary care hospital in Kuppam over 12 months, from January 2023 to December 2023. The sample size, calculated using the formula for prevalence studies, was estimated to be 107, based on a z-score of 1.96, an estimated prevalence of 0.95, and a desired precision of 0.06. The diagnosis of acute ST-elevation myocardial infarction (STEMI) was made using specific criteria: anterior wall myocardial infarction (AWMI) was defined as ST-segment elevation of 2 mm or more in two or more anatomically contiguous precordial leads, while inferior wall myocardial infarction (IWMI) required ST-segment elevation of 1 mm or more in two or more contiguous inferior leads. Patients meeting these criteria, along with elevated cardiac markers, were diagnosed with either AWMI or IWMI.

Study Procedure

Patients presenting with central chest pain underwent a detailed cardiovascular examination and serial electrocardiograms (ECGs) to confirm a diagnosis of acute ST-segment elevation myocardial infarction (STEMI) based on study criteria. Following diagnosis, they were admitted to the intensive cardiac care unit and treated according to standard protocols. Angiography was performed within 15 days of admission. Patients were excluded from the study if their ST-segment elevation was due to causes other than myocardial infarction, if they had left bundle branch block (LBBB), baseline ECG abnormalities (e.g., paced rhythm or Brugada syndrome), or a history of prior myocardial infarction. A total of 107 patients met the inclusion criteria, provided written informed consent, and had their socio-demographic and clinical details recorded. Tests included ECG before, during, and after thrombolytic therapy, percutaneous transluminal coronary angiography, and echocardiography. ECG changes in specific leads and established criteria for identifying the culprit artery and lesion location were compared to angiographic findings, which served as the gold standard.

Data Analysis

All the analysis was done in SPSS version 21. For descriptive statistics of categorical variables, frequency and percentage analysis was used and mean with standard deviation was reported for continuous variables. To determine the association between categorical variables, chi square test was employed vs Pearson correlation co-efficient for continuous variables. Diagnostic accuracy was measured in terms of sensitivity, specificity, Negative Predictive Value (NPV) and Positive Predictive Value (PPV). All the analysis was carried out at 5% level of significance with a P value <0.05 considered as statistically significant.

RESULTS

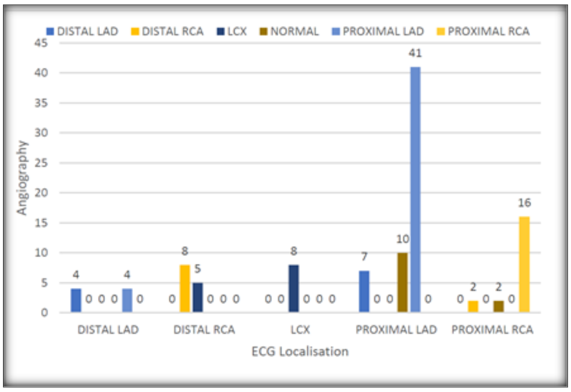

Figure 1: Correlation of angiographic localisation with ECG localisation

The study consists of 107 patients among which, mean (SD) age was 50.92 (8.95) years. The majority of patients in our study were in the 51-60 years age group 42 (39.3%), followed by 41-50 years with 30 (28%), and 31-40 and over 61 years groups, each comprising 16 (15%); the least was observed in <30 years 3 (2.8%). 84.1% of patients in the study are males. Majority of the patients had anterior wall MI consisting of 66 patients (61.7%) followed by Inferior wall MI consisting of 41 patients (38.3%) and 81 patients were thrombolysed, the rest 26 patients (24.3%) were not thrombolysed. Of 107 patients that underwent electrocardiogram, based on which the occluded vessel localized, 58 patients the vessel affected was proximal LAD followed by Proximal RCA in 20 patients, 13 patients had Distal RCA occlusion and 8 patients had Distal LAD and LCX occlusion each. Of 107 that underwent Angiogram, based on which the occluded vessel localized, 45 patients the vessel affected was proximal LAD followed by Proximal RCA in 16 patients, 13 patients had LCX occlusion and 11, 10 patients had Distal LAD and Distal RCA occlusion respectively. 12 patients had normal angiographic findings [Table 1].

The localisation of affected vessel by ECG in comparison with the gold standard angiogram is statistically significant with a chi square of 233.591 and p value <0.001 as depicted in Figure 1. 10 of the normal patients were diagnosed with proximal LAD occlusion on ECG.

Table 2 shows the association between ECG and angiography in diagnosis of occlusion. The sensitivity, specificity, NPV and PPV of each is highlighted in Table 3. ST elevation in L3> L2 used for localising RCA occlusion had a diagnostic accuracy with sensitivity and specificity of 92.31% and 91.36% respectively whereas the sensitivity of ST depression in aVL>L1 and ST elevation > 1mm and upright T in V4R was lower at 50%, and 56.25% on ECG respectively. The sensitivity of heart block on ECG in diagnosing RCA occlusion was only 12.50%, with 100% specificity. For ST depression L2, L3, aVF, Q wave in aVL and RBBB on ECG in diagnosing Proximal LAD occlusion, sensitivity was 39.13%, 38.64% and 6.82% respectively. The sensitivity of isoelectric ST segment in L2, L3, aVF on ECG in diagnosing Distal LAD occlusion was 54.55% with 82.29% specificity. The association was found to be statistically significant between occlusion detection through ECG and Angiography for most except for Q wave in aVL and RBBB.

Table 1: Descriptive statistics of socio-demographic and clinical characteristics of study participants, (N=107)

Variable	Frequency	Percentage
Age (in years)		
<30	3	2.8
31-40	16	15.0
41-50	30	28.0
51-60	42	39.3
>61	16	15.0
Gender		
Male	90	84.1
Female	17	15.9
Type of myocardial infarction (MI)		
Anterior wall MI	66	61.7
Inferior wall MI	41	38.3
Thrombolysis		
Non thrombolysed	26	24.3
Thrombolysed	81	75.7
ECG occluded vessel localisation		
Distal LAD	8	7.5
Distal RCA	13	12.1
LCX	8	7.5
Proximal LAD	58	54.2
Proximal RCA	20	18.7
Angiographic occluded vessel localisation		
Distal LAD	11	10.3
Distal RCA	10	9.3
LCX	13	12.1
Normal	12	11.2
Proximal LAD	45	42.1
Proximal RCA	16	15.0

Table 2: Association between ECG and Angiogram amongst 107 participants, (N= 107)

Variable				P-value
Angiography- RCA occlusion				
		No (n= 81)	Yes (n=26)	
RCA occlusion: ST elevation in L3>L2	No	74	2	<0.001
	Yes	7	24	
RCA occlusion: ST depression in aVL>L1	No	77	13	<0.001
	Yes	4	13	
Angiography- proximal RCA occlusion				
		No (n= 91)	Yes (n=16)	
RCA Occlusion: ST elevation > 1mm and upright T in V4R	No	87	7	< 0.001
	Yes	4	9	
RCA Occlusion: Discordant ST segment in V1 and V2	No	89	7	<0.001
	Yes	2	9	
RCA Occlusion- Heart Block	No	91	14	0.001
	Yes	0	2	
Angiography- Proximal LAD occlusion				
		No (n=63)	Yes (n=44)	
Proximal LAD Occlusion: ST elevation V1 >2.5 mm	No	55	28	0.004
	Yes	8	16	
Proximal LAD Occlusion: ST elevation in aVR	No	55	26	0.001
	Yes	8	18	
Proximal LAD Occlusion: ST depress- ion L2, L3, aVF	No	54	29	0.016
	Yes	9	15	
Proximal LAD Occlusion: Q wave in aVL	No	48	27	0.099
	Yes	15	17	
Proximal LAD Occlusion: RBBB	No	62	41	0.16
	Yes	1	3	
Angiography- Distal LAD occlusion				
		No (n=96)	Yes (n=11)	
Distal LAD Occlusion: isoelectric ST segment in L2, L3, aVF	No	79	5	0.005
	Yes	17	6	

Table 3: Sensitivity, specificity, NPV and PPV between ECG and angiography amongst 107 study participants. (N= 107)

Variable	Sensitivity	Specificity	NPV	PPV
Angiography RCA * ST elevation in L3>L2	92.31%	91.36%	93.37%	77.42%
Angiography RCA * ST depression in aVL>L1	50%	95.06%	85.56%	76.47%
Angiography Proximal RCA * ST elevation > 1mm and upright T in V4R	56.25%	95.60%	92.55%	69.23%
Angiography Proximal RCA vs Discordant ST segment in V1 and V2	56.25%	97.80%	92.71%	81.82%
Angiography Proximal RCA * RCA Occlusion- Heart Block	12.50%	100%	86.67%	100%
Angiography Proximal LAD * Proximal LAD Occlusion: ST elevation V1 >2.5 mm	36.36%	87.30%	66.27%	66.67%
Angiography- Proximal LAD * Proximal LAD Occlusion: ST elevation in aVR	39.13%	87.30%	66.27%	69.23%
Angiography- Proximal LAD * Proximal LAD Occlusion: ST depress- ion L2, L3, aVF	34.09%	35.71%	65.48%	13.16%
Angiography- Proximal LAD * Proximal LAD Occlusion: Q wave in aVL	38.64%	76.19%	64.0%	53.13%
Angiography- Proximal LAD * Proximal LAD Occlusion: RBBB	6.82%	98.41%	60.19%	75.0%
Angiography- Distal LAD * Distal LAD Occlusion: isoelectric ST segment in L2, L3, aVF	54.55%	82.29%	94.05%	26.09%

DISCUSSION

This hospital-based descriptive study, carried out in the PESIMSR Kuppam Department of Medicine. Between January 2023 and December 2023, a total of 107 patients with acute STEMI who had coronary angiograms were evaluated.

Demographic characteristics

Studies on ST-segment elevation myocardial infarction (STEMI) have shown variations in the age distribution of patients over 40 years old. Sharma et al. documented an average age of 54.71 years,[4] while Shah et al.'s study found an average age of 54.[5] years. Multiregional studies such as CREAT-ECLA (India region) and INTERHEART reported mean ages of 55 years and 56.29 years, respectively.[6] In our study, the mean age was 50.92 years, aligning closely with findings from these other investigations. These diverse age distributions underscore the importance of considering demographic factors in understanding and managing STEMI. The studies carried out in India revealed a small male predominance. In the research by Jayachandra S et al. carried out in Andhra Pradesh, India indicated about equal distribution of men and girls.[7] This may be as a result of how the study's patients were chosen, the severity of the illness, or the high fatality rate.

Type of Myocardial Infarction

In our analysis, anterior wall MI was the most common kind of patient injury, accounting for 66 patients (61.7%), followed by inferior wall MI, which included 41 patients (38.3 percent).

RCA occlusion

Studies by Herz et al. highlighted ST segment elevation in lead III and depression in lead aVL as prominent features of RCA occlusion.[8] Zimetbaum et al. and Radhakrishnan Nair et al. found these criteria to possess 90% sensitivity, 71% specificity, 94% positive predictive value, and 70% negative predictive value.[9,10] Our study replicated these findings, yielding similar results. Notably, employing lead III for ST segment elevation detection demonstrated 92.31% sensitivity and 91.36% specificity, with a statistically significant p value of 0.001 for each criterion.

LCX obstruction

In our study of LCX obstruction, employing Herz et al.'s criteria revealed significant ST segment elevation in lead II compared to lead III,[8] aligning with findings from Zimetbaum et al. T wave inversion in lead V4R and isoelectric ST segment in lead I aided LCX blockage prediction when ST elevation was equal in leads II and III.[9] ST elevation in lead II/III exhibited the highest sensitivity (77.27%), while ST V4R with negative T wave showed the lowest (27.27%).

Proximal RCA occlusion

In our study of proximal RCA occlusion, we utilized ECG criteria from Braat et al. indicating positive T wave and ST segment elevation ≥1mm in lead V4R.[11] These criteria showed 56.25% sensitivity, 95.60% specificity, 69.23% PPV, and 92.55% NPV. Mahmoud et al.[12] found ST elevation in lead III/lead II >1 had 85% sensitivity, while Bairey et al. demonstrated 95% sensitivity with ST in I/aVL.[13] Birnbaum et al. highlighted ST depression in I/aVL as an early indicator of RCA blockage. Lead III's higher ST elevation than lead II was useful for predicting RCA occlusion. ST depression in I/aVL was specific to RCA blockage.[14] Herz et al. reported sensitivity ranging from 55% to 94% in individuals with inferior wall MI.[8] Birnbaum et al. found higher sensitivity and specificity using the ratio of ST V3 to ST III 0.5.[14] Kosuge et al. reported similar results with the ratio of ST V3/ST III in acute IWMI.[15]

Proximal LAD occlusion

It can lead to anterior wall infarction, often diagnosed by ST segment elevation in consecutive precordial leads. Engelen et al. and Tamura et al. developed diagnostic standards for this condition.[16,17] In our analysis, we compared variables used in localizing LAD occlusion to Engelen et al., and Zimetbaum et al., studies.[16,9] Our sensitivity and NPV closely mirrored Engelen et al.'s findings, but lower PPV and specificity were likely due to 10 MI patients with normal angiographic results, possibly reflecting aberrant coronary function, such as spasm, common in young smokers, leading to re-canalization after the acute event.[16]

Locating the occlusion site in an anterior STEMI

In anterior STEMI, LAD obstruction often dictates prognosis, with proximal occlusion linked to worse outcomes. Fiol et al.[18] proposed ECG criteria for identifying proximal LAD blockage, but our study found inadequate sensitivity, likely due to differing inclusion criteria and sample sizes. We utilized a 1 mm cutoff for ST elevation and found RBBB negatively impacted reliability of ST depression in V6. Specificity and PPV were high for criteria like ST depression in II, III, aVF, and aVR, but sensitivity and NPV were lower. The complex anatomy around LAD occlusion site, proximity to D1, and involvement of anterolateral wall can lead to mixed ECG findings, explaining the varied diagnostic performance.[9]

Differentiation of RCA from LCA as IRA in inferior STEMI

In distinguishing between RCA and LCA as the culprit artery in inferior STEMI, various ECG parameters and algorithms have been studied. Fiol's and Tierala's algorithms demonstrated high specificity and NPV for LCA diagnosis and high sensitivity and PPV for RCA diagnosis, with significant discriminating power.[19] A vectorial approach considering both frontal and horizontal planes is essential. Single criteria based on STD ratios between leads facing right or inferior versus left or backward had comparable diagnostic performance with the algorithms. Limitations of conventional approaches include low sensitivity (e.g., ST-segment depression in lead I) or specificity (e.g., ST-segment depression in aVL). A vectorial approach improves diagnosis accuracy, especially considering both planes. The differences in ECG criteria performance may be influenced by factors like lower LCA prevalence and a wider spectrum of ECG expression in LCA occlusion. Prevalence of left dominance also impacts diagnosis accuracy, with both algorithms more likely to misdiagnose left dominance cases.

The current investigation's findings generally demonstrated the value of admission ECGs in patients with acute inferior myocardial infarction. The ECG is a valuable tool for early intervention, planning revascularization, and locating the damaged artery. The current study's limitation was that coronary angiography was delayed and not performed right immediately after the patient appeared, which made it difficult to identify the responsible lesion. This is especially true when several vessels are involved or when thrombolytic treatment has been applied.

CONCLUSION

ECG remains a crucial, non-invasive tool for localizing the culprit vessel in STEMI. However, CAG remains the gold standard for accurate diagnosis, especially in complex cases. Timely integration of both tools can improve outcomes in STEMI patients.

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