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Original Article

Internal Medicine Section

Correlation of Standard ECG with 2D-Echo and Serum Troponin I in Locating the Site of Myocardial Infarction and its Extent- An Observational Study

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ABSTRACT

Introduction: Cardiovascular diseases are the leading causes of death in developed countries, and its incidence is on the rise in developing countries. Electrocardiogram (ECG), 2 Dimensional Echocardiography (2D-Echo) and myocardial injury biomarkers help in the diagnosis, prognostification of Myocardial Infarction (MI).

Aim: To correlate the findings of ECG, 2D-Echo and Troponin I levels in locating the site and extent of MI.

Materials and Methods: This observational study was conducted in the Cardiology Intensive Care Unit (ICU)/ward, PES Hospital, Kuppam, Andhra Pradesh, India, from January 2019 to June 2020. A total of 99 patients of acute MI were studied at baseline, and repeat 12 lead ECG, 2D-Echo and serum troponin I levels were recorded. Ejection Fraction (EF) was estimated from the QRS score by means of a formula, and Echocardiographic correlation was obtained on the same day with ECG-QRS scoring by direct estimation of EF in 'Q' wave infarction. High sensitivity cardiac Troponin – I was measured at the time of hospitalisation and repeated at six hours if required, and its levels were correlated to the extent of MI i.e., Left Ventricular Ejection Fraction (LVEF). The categorical data were analysed using Chi-square test and $p<0.05$ was considered as statistically significant. Regression analysis was done for associated factors.

Results: There was better correlation between EF calculated from ECG-QRS scoring system and 2D-Echo ($r=0.78$, p-value <0.001). There was poor correlation between serum Troponin I levels at admission, and extent of MI i.e., LVEF as estimated by ECG and 2D-Echo ($r=-237.13$, $p=0.334$ and $r=-120.78$, $p=0.585$). There was a significant correlation between serum Troponin I levels at 72 hours of chest pain or peak values and extent of MI i.e., LVEF as estimated by ECG and 2D-Echo ($r=-1446.14$, $p<0.001$ and $r=-1354.42$, $p<0.001$).

Conclusion: The location of MI, seen on ECG, correlated broadly with those seen on 2D-Echo. 2D-Echo was able to elaborate regional wall motion abnormalities in detail when compared to the ECG. LVEF can be calculated from ECG at bedside in Q wave infarction, which correlated fairly with 2D-Echo findings.

Keywords: Electrocardiogram QRS scoring system, Left ventricular ejection fraction, Q wave infarction, Regional wall motion abnormalities

INTRODUCTION

Ischaemic Heart Disease (IHD) is the cause of 25-30% of deaths in most industrialised countries [1]. Various methods such as ECG and wall motion abnormality by 2D-Echo and myocardial injury biomarkers help in the diagnosis, prognostification of MI. These investigations are non invasive and can be done at less advanced centres [2]. In 12 lead ECG, the site of MI can be localised depending upon the leads showing typical changes of infarction. Massive anterior infarction is shown by the typical changes of infarction in the chest leads from V1-V6 and/or in leads I and augmented Vector Left (aVL). Anteroseptal infarction is shown by changes in V1 to V3 while apical infarction is shown in V4-V6. Inferior MI is evident by Q wave in standard leads II and augmented Vector Foot (aVF), which persist after deep inspiration. Anterolateral infarction is present when typical changes are present in standard leads I and avL as well as in chest leads V5 and V6. Posterior or posterolateral wall infarction induces changes in leads placed over the back of the heart, such as leads V7 to V9 [3].

2D-Echo is an excellent technique for detecting the early changes in function, which occurs with Acute Myocardial Infarction (AMI) [4]. One of the principle ways of detecting ischaemic muscle is that its motion is altered almost immediately after ischaemic [5]. The major determinants of the immediate and long term outcome of AMI are the size of the infarct, and the functional status of the residual myocardium. The value of the ECG in diagnosis and localisation of an AMI is well established [6-8].

The importance of ECG for measuring the size of an infarct or for assessing left ventricular function has not been well defined. Palmeri ST et al., developed a QRS scoring system based on computer simulation of the sequence of ventricular activation. Their purpose was to evaluate the usefulness of the 12-lead ECG and a simplified version of the QRS scoring system for assessing left ventricular function after MI [9].

Cardiac Magnetic Resonance Imaging (MRI) with high spatial resolution, reproducibility, and the ability to detect small infarctions would have been an appropriate alternative for accurate quantification of infarct size and extent of MI. However, its use for routine assessment of infarct size in daily practice has been limited owing to high expenses and low availability and was not performed in the present study population [10].

The present study was conducted to correlate the ECG findings with 2D-Echo in locating the site of AMI and to correlate the ECG and 2D-Echo findings with the serum Troponin I levels in determining the extent of AMI.

MATERIALS AND METHODS

This observational study was conducted in Cardiology ICU/ward, PES Hospital, Kuppam, Andhra Pradesh, India, from January 2019 to June 2020. Institutional Ethical Committee (IEC) approval was obtained (No: PESIMSR/IHEC/15/2018) was obtained. The study was conducted on 99 patients admitted to Coronary Care

Unit (CCU), in the Department of General Medicine, PESIMSR, Kuppam.

Sample size calculation: Sample size was calculated using the formula mentioned below:

Formula

$$n=\frac{Z^2_{1-\alpha/2}*p(1-p)}{d^2}$$

Calculation

$$n=\frac{1.96^2*0.628(1-0.628)}{0.095^2}=99$$

Inclusion criteria:

Patients above 18 years of age and satisfying World Health Organisation (WHO) criteria for the diagnosis of acute MI were included [11].

Exclusion criteria:

a. Patients presenting with:

i. Previous history of MI.

ii. Left ventricular hypertrophy.

iii. Intraventricular conduction defects, hemi-block, bundle branch blocks and Complete AV block.

iv. Valvular heart disease.

v. Cardiomyopathy.

vi. Pericardial diseases.

vii. Congenital heart disease.

viii. Previous cardiac surgeries.

b. Patients having renal failure.

Study Procedure

Baseline and repeat 12 lead ECG, 2D-Echo, serum Troponin I was done. ECG was performed at the time of admission for diagnosis of MI. The criteria consisted of ST segment elevation of ≥2 mm, 0.08 second from J point in ≥2 related electric fields, with typical evolutionary changes or presence of new pathological Q waves [12]. Continuous cardiac monitoring was done and patients were treated with generally accepted protocols of CCU. As soon as feasible, a 2D-Echo was performed by means of commercially available mechanical sector scanner. With the patient in left lateral decubitus position, multiple parasternal long axis views, short axis and apical views were taken to study regional wall motion abnormalities and for estimation of LVEF, in all 99 patients with AMI. ECG was recorded on a standard ECG machine at a paper speed of 25 mm/sec. Artifactual recordings were eliminated. ECG showing the presence of first Q wave in post MI were taken and the day of evolution of Q waves were noted. From such a reading the EF was estimated using the QRS scoring of Wagner GS et al., [13]. The scoring was based primarily on the duration of the 'Q' and 'R' waves on a 12-lead ECG and secondarily on the magnitude of the R/Q and R/S with a maximum of 29 points possible. LVEF was estimated from the QRS score by means of a formula [14].

LVEF (%)=60-(3×QRS score)

Echocardiographic correlation was obtained on the same day of ECG QRS scoring, by direct estimation of EF in 'Q' wave infarction. High sensitivity cardiac Troponin- I was measured at the time of hospitalisation and repeated at six hours if required, and its levels were correlated to the extent of MI i.e., LVEF.

QRS-scoring system: The QRS scoring system was developed by Carey MG et al., [15], and then subsequently modified by Wagner GS et al., [13]. The scoring system was simplified to include only aspects commonly employed clinically for identification of an infarct and it was modified to meet requirements for sensitivity and specificity. The point score was then calculated from the QRS complexes in 10 of the 12 standard leads [Table/Fig-1].

Lead	Duration (msec)	Score	Amplitude ratios	Score	Max score
I	Q ≥ 30	1	R/Q ≤1	1	2
II	Q ≥ 40	2			2
	Q ≥ 30	1			
aVL	Q ≥ 30	1	R/Q ≤1	1	2
aVF	Q ≥ 50	3	R/Q ≤1	2	5
	Q ≥ 40	2	R/Q ≤2	1	
	Q ≥ 30	1			
V1	Any Q	1	R/S ≤1	1	4
	R ≥ 50	2			
	R ≥ 40	1			
V2	Any Q or R ≤20	1	R/S ≤1.5	1	4
	R ≥ 60	2			
	R ≥ 50	1			
V3	Any Q or R ≤30	1			1
V4	Q ≥ 20	1	R/Q or R/S ≤0.5 R/Q or R/S ≤1	2 1	3
V5	Q ≥ 30	1	R/Q or R/S ≤1 R/Q or R/S ≤2	2 1	3
V6	Q ≥ 30	1	R/Q or R/S ≤1 R/Q or R/S ≤3	2 1	3

[Table/Fig-1]: QRS-scoring system.

STATISTICAL ANALYSIS

The data was entered into MS excel 2007 version and further analysed using Statistical Package for the Social Sciences (SPSS) 20.0. For descriptive analysis, the categorical variable was analysed by using percentages and continuous variables were analysed by calculating mean±Standard Deviation (SD). The categorical data were analysed using Chi-square test and $p<0.05$ was considered as statistically significant. Regression analysis was performed for associated factors.

RESULTS

Out of 99 patients of MI, 44 had AMI (44.4%), 35 patients had inferior wall (35.3%), 15 had anteroseptal (15.1%), 2 had antero-inferior (2.1%), two had posterior wall (2.1%) and 1 had Right Ventricular Myocardial Infarction (RVMI) (1%). Chest pain was the most common presenting symptom, and excessive sweating was the most common associated symptom. Other symptoms noted were breathlessness, epigastric pain, palpitations, vomiting and syncope. The age of the patients ranged from 31 years to 89 years. The maximum numbers of patients (31.3%) were seen in the age group of 61-70 years. The minimum numbers of patients (10.1%) were seen in 31-40 years. Male to female ratio was 2.6:1. The association of age and sex-wise distribution was found to be statistically insignificant $p>0.05$ [Table/Fig-2].

	Gender		Chi-square value	p-value
	Male	Female		
Age (years)	n (%)	n (%)		
<30	0	0	5.5238	<0.238
31-40	9 (12.5)	1 (3.7)		
41-50	15 (20.8)	3 (11.1)		
51-60	20 (27.8)	6 (22.2)		
61-70	20 (27.8)	11 (40.8)		
>71	8 (11.1)	6 (22.2)		
Total	72 (100)	27 (100)		

[Table/Fig-2]: Age and gender distribution.
n=Frequency, %=Percentage, p-value <0.05 significant

An analysis of coronary risk factors among the 99 patients revealed, 52 patients were chronic smokers (52.5%), 42 patients with family history of IHD/Diabetes Mellitus (DM)/Hypertension (42.4%), 38 patients with DM (38.4%), 36 patients with obesity (36.4%), 34 patients with hypertension (34.4%), 31 patients were alcoholic (31.3%), and 48 patients out of 95 patients (for four patients lipid profile could not be done) showed hyperlipidemia (50.5%).

2D-Echo on the 44 patients with AMI on ECG further elaborated that additional regional areas of Left Ventricle (LV) were involved, 12 patients had extensive AMI, 11 patients had apical and anterior wall hypokinesia and rest as shown in the [Table/Fig-3].

Site of Infarction on echo	No. of subjects	Percentage (%)
(Extensive anterior wall MI) Distal septal apex, apical anterior, anteroseptal, anterolateral wall hypokinesia	12	27.2
Apical and anterior wall hypokinesia	11	25
Apical anterior, anterolateral wall hypokinesia	8	18.2
Apical, anteroseptal, anterolateral wall hypokinesia	7	15.9
Anterior wall hypokinesia	4	9.1
Apical anterior, anterolateral, inferoseptum, anteroseptum hypokinesia	1	2.3
Global hypokinesia of LV	1	2.3
No regional wall motion abnormality	0	0
Total	44	100.0

[Table/Fig-3]: Site of infarction on Echo in 44 patients with AMI on ECG.
MI: Myocardial infarction; LV: Left ventricular

2D-Echo of 35 patients with inferior wall MI on ECG showed that, 23 patients had basal inferior wall hypokinesia, eight patients had basal mid inferior, inferoseptal, inferolateral and inferoposterior wall hypokinesia and rest as shown in the [Table/Fig-4].

Site of infarction on echo	No. of subjects	Percentage (%)
Basal inferior wall hypokinesia	23	65.7
Basal mid inferior, inferoseptal, inferolateral and inferoposterior wall hypokinesia.	8	22.8
Inferior and inferoseptal hypokinesia	2	5.7
Inferolateral segment hypokinesia	1	2.9
Global hypokinesia of LV	1	2.9
No regional wall motion abnormality	0	0
Total	35	100.0

[Table/Fig-4]: Site of infarction on echo in 35 patients with inferior wall myocardial infarction on ECG (n=35).

Of the 15 patients who had anteroseptal MI on ECG, 2D-Echo in these patients further revealed that 10 patients had apical and anteroseptal wall hypokinesia, four patients had anteroseptal wall hypokinesia and rest as shown in the [Table/Fig-5].

Site of infarction on echo	No. of subjects	Percentage
Apical and anteroseptal wall hypokinesia	10	66.7
Anteroseptal wall hypokinesia	4	26.7
Anterior and anteroseptal wall hypokinesia	1	6.6
Global hypokinesia of LV	0	0
No regional wall motion abnormality	0	0
Total	15	100.0

[Table/Fig-5]: Site of infarction on Echo in 15 patients with anteroseptal myocardial infarction on ECG (n=15).

2D-Echo on two patients with posterior wall MI on ECG showed that one had inferoseptum, inferoposterior segment hypokinesia, while the other had posterior wall hypokinesia. 2D-Echo in the patient with RVMI further revealed that the patient had RV segment hypokinesia.

LVEF was dichotomised at 40% (>40% and <40%) this cut-off point has been shown to be of major prognostic importance after MI [16]. LVEF by QRS scoring system showed EF <40% in 56/99 patients. Whereas, LVEF by 2D-Echo showed EF <40% in 51/99 patients.

There was a good correlation of EF calculated from ECG QRS scoring system and 2D-Echo in all sub-groups of MI. However, there was better correlation in anterior wall MI, anteroseptal MI and inferior wall MI as shown in the [Table/Fig-6].

Sub-groups of MI	Mean EF by ECG (QRS scoring)	Mean EF by 2D-Echo	Correlation coefficient	p-value
Anterior wall MI (n=44)	39.6±5.2	40.3±5.3	0.81	p<0.001
Inferior wall MI (n=35)	40.9±6.5	42.9±7.7	0.76	p<0.001
Anteroseptal MI (n=15)	40.8±3.1	41.8±3.4	0.73	p<0.001
Antero inferior MI (n=2)	30.5±3.5	32.5±3.5	-	-
Posterior wall MI (n=2)	41.5±4.9	44±5.6	-	-
Right ventricular MI (n=1)	44±0	45±0	-	-

[Table/Fig-6]: Mean Ejection Fraction (EF) as calculated by ECG (QRS scoring) and 2D-Echo in sub-groups of MI patients.
ECG: Electrocardiograph; QRS: Complexes of the ECG; MI: Myocardial infarction; p-value <0.05 significant

There was a fair degree of correlation between EF calculated from ECG and 2D-Echo (r=0.78 and p-value <0.001) [Table/Fig-7].

There was poor correlation between serum Troponin I levels at admission and EF calculated from ECG QRS whereas serum Troponin I levels at 72 hours or peak level and EF calculated from ECG QRS correlated significantly [Table/Fig-8].

Ejection fraction	Mean	SD	Coefficient	p-value
ECG QRS-EF	40.2	5.5	0.78	<0.001
EF by 2D-Echo	41.4	6.2		

[Table/Fig-7]: Regression Analysis of EF calculated by ECG QRS scoring system and 2D-Echo.
ECG: Electrocardiograph; QRS: Complexes of the ECG; EF: Ejection fraction; p-value <0.05 significant

High sensitivity Troponin I at admission		
LVEF by ECG QRS score	Coefficient	p-value
	-237.0733	0.334
High sensitivity Troponin I at 72 hours or peak level		
LVEF by ECG QRS score	Coefficient	p-value
	-1446.094	<0.001

[Table/Fig-8]: Regression analysis of serum Troponin I levels with the extent of MI by ECG QRS score based LV Ejection Fraction (EF).
p-value <0.05 significant

There was poor correlation between serum Troponin I levels at admission and EF calculated from 2D-Echo whereas serum Troponin I levels at 72 hours or peak level and EF calculated from 2D-Echo correlated significantly [Table/Fig-9].

High sensitivity Troponin I at admission		
EF by 2D-Echo	Coefficient	p-value
	-120.7888	0.585
High sensitivity Troponin I at 72 hours or peak level		
EF by 2D-Echo	Coefficient	p-value
	-1354.42	<0.001

[Table/Fig-9]: Regression analysis of Serum Troponin I levels with the extent of MI by Ejection Fraction (EF) calculated by 2D-Echo.
p-value <0.05 significant

DISCUSSION

Ninety nine patients were studied in the present study. The age ranged from 31-89 years. A total of 72 patients were males (72.7%) and 27 patients were females (27.3%). The maximum number of

cases was noted in 61-70 years (33 cases). Less number of cases were noted in 31-40 years (10 cases). The male to female ratio was 2.6:1. Among risk factors, the present study shows that smoking was the commonest risk factor (52.5%), followed by hyperlipidaemia (50.5%), family history of IHD/DM/hypertension (42.4%), DM (38.4%), obesity (36.4%), hypertension (34.4%), alcoholic (31.3%).

ECG and 2D-Echo correlation for site of MI: In present study, out of 99 patients, 44 patients had AMI, 15 patients had anteroseptal MI, 35 patients had inferior wall MI and two patients had anteroinferior MI, two patients had posterior wall MI and one patient had RVMI on ECG. 2D-Echo in these patients further elaborated site of infarction seen on ECG in great detail, thereby, lending credence to the fact, that, 2D-Echo delineates ischaemic changes more extensively.

The present study was in agreement with the findings of many researchers. It reiterates that electrocardiography and 2D-Echo have a good correlation in localising the site of infarction but 2D-Echo was able to elaborate the site of infarction in detail. Hence, clinically ECG can be used as a better tool in diagnosing and localising the site of MI in remote areas where 2D-Echo is not available [17-19].

Correlation of EF calculated from ECG 2D-Echo: In the present study, it was found that there was a good correlation of EF in anterior wall MI, anteroseptal MI and inferior wall MI [Table/Fig-6]. There was a fair degree of correlation between EF calculated from ECG and 2D-Echo with r=0.78 and p-value <0.001 [Table/Fig-7]. A study by Tateishi S et al., concluded that the QRS scoring system can be used as a simple and economical method for estimation of infarct size soon after reperfusion [20]. Barbagelata A et al., concluded that in the reperfusion era, a 12-lead ECG provides a simple, economical means of risk stratification at discharge [21]. Hence, estimation of infarct size soon after reperfusion by the QRS scoring system is simple and economical method. Though the relative inadequacies of this study (as given in limitation of study), relatively fair correlation was obtained between ECG QRS scoring and echocardiographic LV pump function. Hence, this can be used as an additional method of evaluating left ventricular function in 'Q' wave infarction.

Correlation of Serum Troponin I levels with the extent of MI by LV EF calculated from ECG QRS score and 2D-Echo: In the present study, serum high sensitivity troponin I levels at admission did not correlate with LVEF calculated from ECG QRS score and 2D-Echo (r=-237.07, p=0.334 and r=-120.78, p=0.585) [Table/Fig-8,9]. But high sensitivity Troponin I levels at 72 hours of chest pain or peak values correlated with LVEF calculated from ECG QRS score and 2D-Echo (r=-1446.09, p<0.001 and r=-1354.42, p<0.001). Stanley C et al., found that the Troponin I levels, on admission, weakly correlated with LVEF with p-value <0.05, whereas peak Troponin I value correlated well with p<0.001 (135). The index study results were also similar [22]. Ohlmann P et al., reported that cardiac Troponin I concentrations done at the time of admission did not correlate with LVEF, whereas Troponin I levels done from the 3rd to the 72nd hour following Percutaneous Intervention (PCI) correlated with LVEF (p<0.001; R: -0.42 to -0.50). Similar findings were there in the present study too [23]. Hence, serum Troponin I cannot be used as good indicator of extent of MI.

Limitation(s)

However, better correlative values could not be obtained possibly because of certain limitations: Equipment and techniques used in estimation of EF will vary in different studies/Institutes. Standardisation of ECG is required for homogeneity. Ideally the ECG used for scoring should have been performed on the same day or nearest possible day of ECHO study to obtain the best correlation. EF by QRS scoring system cannot be superior to LVEF obtained by 2D-Echo or even used as a substitute because of the following limitations: It cannot estimate infarct size directly. It cannot be used in non Q-wave infarct and acute MI with conduction disturbance. Scoring system cannot be used to exclude diagnosis of a prior or AMI. Different equipment and techniques used in different Institutions may have limitations on the scoring system.

CONCLUSION(S)

The location of MI seen on ECG correlated broadly with those seen on 2D-Echo. However, elaboration of regional wall motion abnormalities could be done in detail by 2D-Echo. LVEF calculated from ECG at bedside in Q wave infarction correlated fairly to 2D-Echo findings. Serum high sensitivity Troponin I levels at admission did not correlate with extent of MI calculated by LVEF. Serum high sensitivity Troponin I levels at 72 hours after onset of chest pain or peak levels documented during admission correlated with the extent of MI calculated by LVEF.

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