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Original research article

Relationship between electrocardiography (ECG) and cardiac troponin T (cTnT) levels, and their association with 2D-echocardiography in evaluating left ventricular function following an acute myocardial infarction

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Abstract

Abstract:
Left ventricular function is the best individual predictor of mortality after acute myocardial Infarction. After acute myocardial infarction (AMI), a patient's prognosis is closely related to the extent of irreversibly damaged myocardium. The cardiac Troponin T (cTnT) has been found to have excellent sensitivity and specificity and is superior to creatine kinase–MB (CK-MB) as indicator of myocardial necrosis. The purpose of the study was to compare the QRS score with left ventricular ejection fraction, relate the score to clinical and biochemical estimates of LVEF.

Material and Methods: The study was carried out in a study group of consecutive 88 patients admitted in ICCU. Serum troponin T concentration was measured between 12 - 48 hours after the onset of chest pain. Standard 12 lead electrocardiograms were recorded at a 25 mm paper speed for the patients who met the preceding entry criteria had a QRS score calculated from the discharge electrocardiogram on the basis of Q and R wave duration and R to Q and R to S amplitude ratios.

Results: Mean age of the patients in present study was 52±12. Most of the patients in our study were in age group 41-60yrs (82.5%). 67% of patients had AWMI and 33% patients had IWMI, 60% patients had dyslipidaemia. There was a strong negative correlation between cTnT level and Echocardiographic LVEF. The relationships between QRS Score and the indices of LV function obtained by Echocardiography performed at the time of ICCU discharge, QRS Score was inversely correlated with LVEF. There was a negative correlation between QRS Score and LVEF.

Conclusion: A strong negative correlation exists between the serum troponin T concentration and left ventricular ejection fraction following the occurrence of a first acute myocardial infarction. Therefore, using serum troponin T concentration can be an effective way to evaluate the LVEF in patients who have experienced their first myocardial infarction.

Keywords: Cardiac troponin T, electrocardiogram, acute myocardial infarction, creatine kinase

Introduction

Left ventricular function is widely regarded as the most significant individual prognostic indicator for mortality following an acute myocardial infarction. The extent of irreversibly damaged myocardium is closely linked to a patient's prognosis after an AM [1]. Assessing the size of the infarct following an acute myocardial infarction (AMI) is a crucial factor in predicting the patient's clinical outcome and establishing the effectiveness and clinical significance of therapeutic interventions [2].

Quantitative histologic estimates of infarct size are regarded as the gold standard, but the method has little clinical relevance. It is desirable to find a simple and reliable method with which to quantify infarct size [3]. Various methods, such as electrocardiography, echocardiography, left ventriculography, radionuclide- based measurements, and the release of cardiac biomarkers, have been proposed [4].

While CK-MB is a useful biomarker for the assessment of myocardial injury, it is not specific to the heart and can also be elevated in other conditions such as skeletal muscle injury. In recent years, other biomarkers such as cardiac troponins have emerged as more specific and sensitive markers of myocardial injury, and are increasingly being used in clinical practice [5]. Although quantitative calculations based on the area under the CK-MB-vs-time curve are seldom made, many physicians use peak CK-MB to get a qualitative estimate of the size of the infarct [6]. The well-known limitations of CK-MB measurements, such as the short duration of increase after AMI, the requirement for repetitive, frequent sampling for evaluation of peak concentrations, the sensitivity to reperfusion status, and the lack of specificity for

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cardiac damage, have stimulated the search for a more suitable biomarker for sizing infarcts [7].

Plasma cTnT is a highly specific cardiac protein that is located in the contractile apparatus of myocardial cells. It is released into the bloodstream slowly after myocardial injury and can be detected in plasma for over 120 hours after an AMI. Reperfusion of the infarct zone has minimal effect on cTnT release, making it a reliable biomarker for estimating infarct size. As a result, plasma cTnT has been widely used for infarct size estimation [8].

The 12-lead surface electrocardiogram (ECG) is cheap, safe, quick, universally available, and well-tolerated by patients. The Selvester QRS score can be applied to the 12-lead ECG once the acute ST-segment deviation has resolved, to estimate infarct size in both anterior and inferior ventricular locations [9]. From the QRS score, the LVEF can be estimated [10]. Both the QRS score and the subsequent LVEF calculation were, however, derived in non reperfused infarcts. Several studies in reperfused infarcts have shown significant correlations between the QRS score, radionuclear perfusion defects, and echocardiographic dyssynergy indices [11]. The ECG QRS Scoring included the complete 50-criteria 32-point Selvester scoring system that has been previously reported and validated [12].

In this study, we applied the QRS score to patients surviving a first acute myocardial infarction. The purpose of the study was to compare the QRS score with left ventricular ejection fraction, relate the score to clinical and biochemical estimates of LVEF.

Materials and Methods

The study was carried out in a study group of consecutive 88 patients admitted in ICCU from July 2015 to July 2018 in the department of medicine of Kamineni Institute Of Medical Sciences, Narketpally satisfying the selection criteria (as per inclusion and exclusion criteria laid down).

Inclusion Criteria: Patients who satisfy the WHO criteria for the diagnosis of acute MI are included

a. A history of ischemic type of chest pain,
b. Evolutionary changes on serially obtained ECG tracings, and
c. A rise and fall in serum cardiac markers.

Exclusion Criteria:
Patients presenting with:

a. Previous history of MI,
b. LVH, intraventricular conduction defects and complete heart blocks
c. Valvular heart disease,
d. Cardiomyopathy,
e. Pericardial diseases,
f. Congenital heart disease,
g. Previous cardiac surgeries, and renal failure.

No control subjects were taken because cTnT is not detected in the peripheral circulation under normal circumstances. Serum troponin T concentration was measured between 12 - 48 hours after the onset of chest pain.

Standard 12 lead electrocardiograms were recorded at a 25 mm paper speed for the patients who met the preceding entry criteria had a QRS score calculated from the discharge electrocardiogram on the basis of Q and R wave duration and R to Q and R to S amplitude ratios. Echocardiograms were obtained using a echocardiographic machine a 3.5 mHZ multiphase array probe in subjects lying in the left lateral decubitus position and supine position.

The echocardiographic techniques and calculations of different cardiac dimensions were performed according to the recommendations of the American Society of Echocardiography. The ejection fraction was obtained using an M Mode method from apical four chamber view. Measurements were made from three consecutive beats, and the average of three beats was used for analysis. LVEF less than 50% was taken as systolic dysfunction.

Statistical Analysis

The relation between LVEF and cTnT concentration; LVEF and QRS score was studied using Pearson’s correlation coefficient, and by systemic analysis of sensitivity and specificity. Patients were initially categorized into two data sets, those with EF < 50% and those with EF > 50%. Fisher's exact- test, or linear regression analysis were applied when appropriate. The most advantageous cut off values to predict mortality were selected from visual inspection of the receiver-operator characteristic curves (ROC).

Results

The study was carried out in a study group of consecutive 88 patients admitted in ICCU. Mean age of the patients in present study was 52±12. Most of the patients in our study were in age group 41-60yrs (82.5%). 66.6% of patients were male and only 36.3% were female. 67% of patients had AWMI and 33% patients had IWMI, 60% patients had dyslipidaemia. It was found to be most common risk factor. Hypertension (57%) and Diabetes (42%) were other significant risk factors, mainly in male patients. Risk factors were much more common in AWMI as compared to IWMI patients (Table 1)

Table 1: Clinical and biochemical characteristics of the study group

Variables	Values
Age (yrs)	52 ± 12
Sex (M/F)	56/32
RWMA(Ant/Inf)	59/29
Thrombolysis (%)	82.9
Dyslipidaemia (%)	60
Hypertension (%)	57
Diabetes Mellitus (%)	42
Smoking (%)	28
Alcohol (%)	51
Cholesterol (mg/dl)	147.7 ± 66
Serum Triglyceride (mg/dl)	139.8 ± 41
Serum LDL (mg/dl)	84.5 ± 27.3
Serum HDL (mg/dl)	38.3 ± 11.8
Serum VLDL(mg/dl)	32 ±13.2

When we assessed the relationship between cTnT and the indices of LV function obtained by Echocardiography performed at the time of ICCU discharge, cTnT was inversely correlated with LVEF (r = -0.4864; *p*<0.0001;)

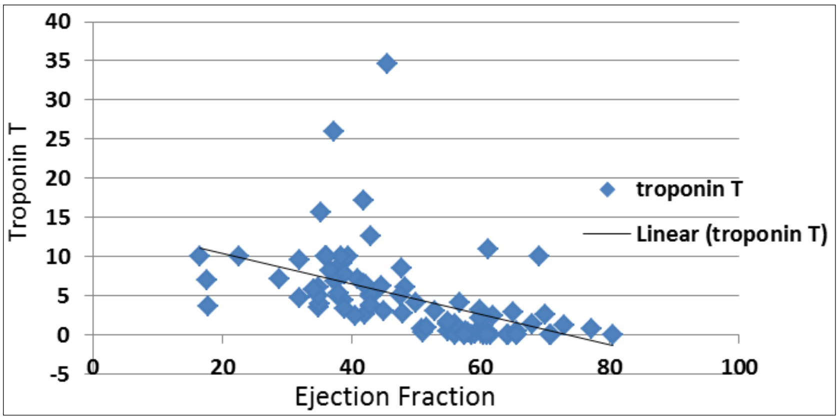

Fig 1: Correlation between cTnT and the Echocardiographic LVEF, in patients with AMI

Table 2 shows the relation between cTnT and LVEF. There was a strong negative correlation between cTnT level and Echocardiographic LVEF. The Pearson's correlation coefficient between cTnT and LVEF was r = - 0.4864 (Fig. 1). The cTnT value was high among patients with LVEF <50%. Which was statistically significant (*p*<0.0001).

Table 2: cTnT levels (mean ± SD) in relation to ejection fraction

Ejection fraction	N	Trop. T µg/ml (mean ± SD)
< 50%	47	7.91 ± 5.82
≥ 50%	41	1.52 ± 2.37

(*p*<0.0001)

Analysis by ROC curve produced an area under the curve of 0.945 (95% CI 0.875 to 0.982) at a cut off left ventricular ejection fraction of 50% (Fig 2). A troponin concentration of > 3.24 µg/ml predicted a left ventricular ejection fraction of < 50% with sensitivity of 91.67% (CI 80 to 97.7) and specificity of 92.5% (CI 79.6 to 98.4).

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 03, 2023

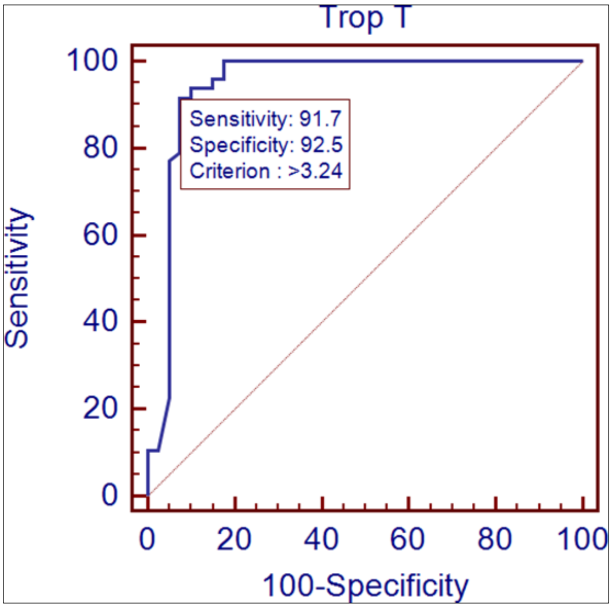

Fig 2: ROC curve analysis for cTnT measured at CCU as a diagnostic test of LVEF <50% in the acute phase of myocardial infarction

The result of re-analysis to examine the effect of reperfusion by excluding 15 patients who did not receive thrombolysis was no different from analysis of all patients.

Table 3 shows the sensitivity and specificity of cTnT to predict LVEF. It was found that cTnT concentration > 3.24 µg/ml predicted LVEF of < 50% with a sensitivity of 91.67% and specificity of 92.5%.

Table 3: cTnT level and ejection fraction

Troponin T	EF<50%	EF>50%
≥ 3.24	43(a)	4(b)
< 3.24	4(c)	37(d)

a = true positive c = false negative b = false positive d = true negative

The relationships between QRS Score and the indices of LV function obtained by Echocardiography performed at the time of ICCU discharge, QRS Score was inversely correlated with LVEF (r = -0.5834; *p*<0.0001; Fig.3)

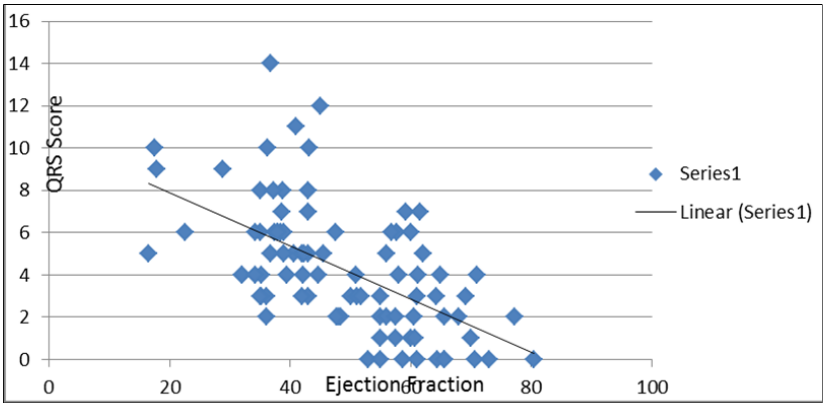

Fig 3: Correlation between QRS Score and the Echocardiographic LVEF, in patients with AMI

Table 4 shows the relation between QRS Score and LVEF. There was a negative correlation between QRS Score and LVEF. The Pearson's correlation coefficient between QRS Score and LVEF was r= -0.5834. The QRS Score was high among patients with LVEF < 50%. Which was statistically significant (*p*< 0.0001).

Table 4: QRS Score (mean ± SD) in relation to ejection fraction.

Ejection fraction	N	QRS Score(mean ± SD)
< 50%	47	5.8 ± 2.7
≥ 50%	41	2.4 ± 2.1

(*p*< 0.0001)

Analysis by ROC curve produced an area under the curve of 0.831 (95% CI 0.736 to 0.903) at a cut off left ventricular ejection fraction of 50% (fig 4). The QRS Score of > 6 predicted a left ventricular ejection fraction of < 50% with a sensitivity of79.2% (CI 65 to 89.5) and specificity of 70.2% (CI 53.5 to 83.4).

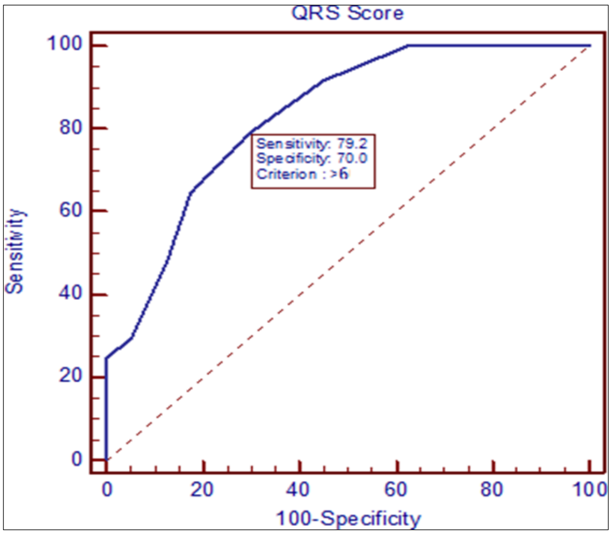

Fig 4: ROC curve analysis for QRS Score measured at CCU as a diagnostic test of LVEF <50% in the acute phase of myocardial infarction.

Table 5 shows the sensitivity and specificity of QRS Score to predict LVEF. It was found that QRS Score > 6 predicted LVEF of < 50% with a sensitivity of 79.2% and specificity of 70.2%.

Table 5: QRS Score and ejection fraction.

QRS Score	EF<50%	EF>50%
≥ 6	43(a)	19(b)
< 6	4(c)	22(d)

a = true positive c = false negative b = false positive d = true negative

QRS score and prediction of ejection fraction.

Of the 88 patients whose predicted left ventricular ejection fraction was compared with subsequent measured ejection fraction. Left ventricular ejection fraction was 47.1% ± 8.9% by ECG versus 48.6% ± 13.8 % by Echocardiography. The correlation between predicted and measured ejection fraction is r = 0.5834[*p*< 0.000 1] Fig.No.5).

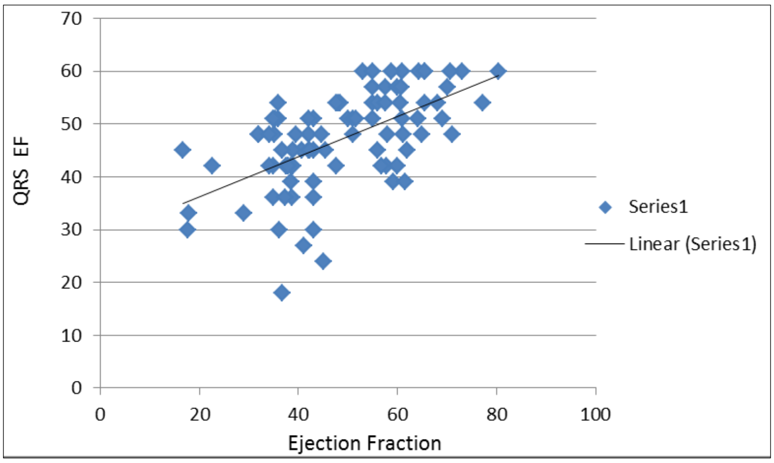

Fig 5: Correlation between QRS EF and the Echocardigraphic LVEF, in patients with AMI.

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 03, 2023

Discussion

Serum troponin T is accepted as a highly reliable biochemical marker [13] for detecting myocardial damage, and its use in the diagnosis of acute myocardial infarction is increasing. Data show that serum troponin T is related to the amount of myocardial damage [14], but the relation between serum troponin T and impairment of left ventricular function after acute myocardial infarction has not been examined. The present study shows a strong negative correlation between serum troponin T concentration measured 12–48 hours post myocardial infarction and Echocardiographic left ventricular ejection fraction.

Analysis of the relation between troponin T and Echocardiographic left ventricular ejection fraction by ROC curve shows that a troponin T concentration of >3.24 μg/ml is a sensitive (91.67%) and specific (92.5%) indicator of a left ventricular ejection fraction of < 50% after a first myocardial infarction. The result of re-analysis to examine the effect of reperfusion by excluding 15 patients who did not receive thrombolysis was no different from analysis of all patients.

Troponin T has practical advantages over other markers in the assessment of left ventricular ejection fraction. After acute infarction, troponin T has a peak value at 12 hours from the onset of pain, if successful reperfusion has occurred [15], corresponding to washout of the cytoplasmic fraction. The plateau phase of troponin T, however, lasts up to 48 hours and represents an integrated estimate of myocyte necrosis. The peak value will therefore be missed in samples taken 12–48 hours after admission but there is a large time window. This makes repeated sampling unnecessary and represents a cost and time effective method of diagnosis and quantification.

This is in contrast to creatine kinase MB or myoglobin for which multiple measurements are required and whose values are affected by thrombolysis. In our study, cTnT levels closely correlated with Echocardiographic LV Ejection Fraction. Our results corroborate those of earlier clinical studies in which cTnT release, not a single-point measurement, was used to assess infarct size [16].

Furthermore, our findings in living patients are consistent with those obtained experimentally in dogs by Remppis et al. [17], who found a good correlation between cTnT concentrations 96 h after the onset of ischemia and the pathoanatomic infarct size as quantified by the 2,3,5- triphenyltetrazolium chloride method.

In clinical practice, estimation of AMI size based on cTnT determination on a single plasma sample at CCU would facilitate the choice of appropriate care, leading to more efficient and economic use of healthcare facilities. This approach appears to be more useful than analyzing cumulative cTnT release, as proposed previously because of the requirement of repetitive sampling and a possible incomplete recovery of cTnT [18].

LVEF is a very powerful prognostic indicator after AMI [19]. A strong inverse relationship exists between LV function and patient outcome, with rapidly increasing mortality rates at LVEFs below 40 % [20]. In the present study most of the patients (i.e., 82.5%) belong to the age group of 41-60 years and (2.5%) of the patients are below 40 years, (15%) of patients are above 70 years. Youngest patient in present study is 35 year old and oldest patient in present study is 70 year old. Age group in the present study is comparable with other studies. In the present study, males were 63.6% and only 36.3% were females, which can be compared with Rao et al, [21] Kanna et al. [22] study.

The purpose of this study was to elucidate the prognostic value of determining the cTnT level on day 3 or 4 after AMI. Serum cTnT levels on day 3 or 4 after AMI were measured in 121 patients with mean follow up period was 526 days. There were 12 deaths (9 cardiac and 3 non cardiac) during the follow up period. By Kaplan-Meier analysis, patients with cTnT levels higher than the median levels (6.9ng/ml) had a significantly mortality rate than those with submedian levels.

By multivariate Cox proportional-hazards regression analysis, the serum cTnT was an independent predictor of the long term outcome after AMI. Furthermore, in patients with a first AMI, the serum cTnT level exhibited a significant negative linear correlation with left ventricular ejection fraction assessed 4 weeks after AMI. Increased serum cTnT levels on day 3 or 4 after AMI are a powerful noninvasive predictor of poor long term prognosis, reflecting residual left ventricular function after AMI.

Panteghini et al. [23] demonstrated that there is a significant correlation between cTnT and the perfusion defect size at SPECT. cTnT was inversely related to LV ejection fraction assessed both early and 3 months after. cTnT >2.98ng/ml predicted a LVEF <40% at 3 months with a sensitivity of 86.7%,specificity of 81.4%. A single cTnT measurement at CCU discharge after AMI is useful as a noninvasive estimate of infarct size and for the assessment of LV function in routine clinical setting.

In the present study, there is a significant negative correlation between QRS score and echo cardiographic LV ejection fraction measured at the time of hospital discharge. The Pearson's correlation coefficient between QRS Score and LVEF. The QRS Score was high among patients with LVEF < 50% which was statistically significant. The QRS Score of > 6 predicted a left ventricular ejection fraction of < 50% with sensitivity of 79.2% (CI 65 to 89.5) and specificity of 70.2%.

As expected, the QRS score is also related to estimates of left ventricular damage, made by cardiac markers. Because QRS score correlates well with left ventricular function, it also gives a good prediction of survival and it is likely that it will be useful for identifying high risk patients. In this study, we used the QRS score in patients with a first infarction; it is still unclear whether it is as useful in patients who have

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had more than one infarction.

To conclude, serum troponin T concentration has a strong negative correlation with left ventricular ejection fraction after first acute myocardial infarction, and hence can be used to assess the LVEF in patients with first myocardial infarction. A level of >3.24 ng/ml provided a good indication for LVEF below 50% with a sensitivity of 91.67% (CI 80 to 97.7) and specificity of 92.5% (CI 79.6 to 98.4) and thus can identify patients with higher risk.

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