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The Role of Electrocardiogram DETERMINE Score in Prediction of Coronary Artery Disease Severity

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Abstract

Background: A major cause of mortality and disability on a global scale is myocardial infarction (MI). These days, the most reliable way to detect and measure MI is via cardiovascular magnetic resonance imaging (CMR). **Aims and Objectives:** To evaluate the effectiveness of the Electrocardiogram DETERMINE Score in predicting the severity of coronary artery disease (CAD) in patients who have experienced an Acute Myocardial Infarction (AMI) & to assess improvements in left ventricular function at 6 months following coronary artery bypass grafting (CABG). **Subjects and Methods:** This Observational cohort study was done at the Cardiology and Radiology department and cardiac surgery department, Al-Azhar university hospitals and Helwan University hospital. The study involved 700 cases who patients diagnosed with Acute Myocardial Infarction and fulfilled specific criteria for selection. **Result:** There was highly statistically significant relation between Myocardial infarction size and ECG Marker Score as mean infarct size elevated When the number of ECG markers increased. There was a highly statistically significant relation between myocardial infarct segments, myocardial infarction size and improvement of cardiac function 6 months post-CABG. **Conclusion:** The study found that larger myocardial infarctions corresponded with higher DETERMINE Scores. It concluded that an ECG-based score better estimates infarct size than LVEF alone. Additionally, there was a significant statistical correlation between the size and segmentation of myocardial infarction and better cardiac function six months after CABG.

Keywords

Electrocardiogram DETERMINE Score, Coronary Artery Disease, Outcome, Acute Myocardial Infarction, Coronary Artery Bypass Grafting

1. Introduction

Myocardial infarction (MI) is a prominent reason for mortality and impairment on a global scale. CMR is now regarded as the most reliable method for observing & measuring myocardial infarction (MI) [1].

CMR has demonstrated that the existence and magnitude of myocardial infarction (MI) can forecast several unfavorable cardiovascular consequences, such as mortality, repeated MI, irregular heart rhythms, congestive heart failure, angina, and the need for revascularization procedures [2]-[4].

Electrocardiography is the primary diagnostic technique used in clinical practice to assess patients with suspected ischemic heart disease due to its safety, affordability, and widespread accessibility [5] [6].

Patients with a history of MI may exhibit various electrocardiogram (ECG) abnormalities, such as the presence of Q waves (QW), fragmented QRS (FQRS) [7], and T wave inversions (TWI) [8] [9].

Currently, these irregularities are regarded as binary indicators for the existence or nonexistence of infarction, and their separate correlation with the extent of the infarct has not been investigated. CABG is presently the established treatment approach for individuals diagnosed with ischemic cardiomyopathy (ICM) [10]. Nevertheless, several previous studies have reported different rates of improvement in heart function after CABG [11] [12].

The purpose of this study was to investigate the role of the Electrocardiogram DETERMINE Score in predicting the severity of coronary artery disease in patients with acute myocardial infarction. Additionally, the study aimed to evaluate the improvement in left ventricular function six months after undergoing CABG.

2. Patients and Methods

This Observational cohort study was done at the Cardiology and Radiology department and cardiac surgery department, Al-Azhar university hospitals and Helwan University hospital. The study involved 700 cases who Patients diagnosed with Acute Myocardial Infarction and fulfilled specific criteria for selection.

Inclusion criteria: Patients presenting with signs of Acute MI, confirmed diagnosis of AMI through clinical evaluation and laboratory tests, Availability of Electrocardiogram (ECG) data for scoring.

Exclusion criteria: Patients with previous history of severe cardiac conditions unrelated to CAD, Incomplete clinical or ECG data, Patients unwilling to provide informed consent.

2.1. Methods

This protocol was followed for all patients:

Complete history-taking: Personal history, complaint & its duration, current history, past medical history, & past surgical history Physical examinations, **Laboratory Investigations:** Cardiac Biomarkers, Complete blood count (CBC), Serum electrolytes, Renal function tests, Liver function tests, Lipid profile, Blood glucose levels (fasting glucose, HbA1c)

Twelve-Lead ECG: (Echocardiography was performed to determine infract size of patients with MI after that those patients were managed by medical treatment or (PCI) or (CABG))

The ECG core laboratory performed analysis on all patient ECGs. With the exception of lead aVR (augmented Vector Right), all of the patient's electrocardiogram leads were examined for the existence or absence of irregular ECG signals. Any ECG study where more than one lead was unintelligible due to artifact or noise was not included. The data was pre-processed by defining abnormal ECG signs according to established criteria in the literature. If the Q wave was either nonexistent, had an amplitude ratio of more than 0.25, or lasted longer than 40 ms, it was deemed a pathologic Q wave (QW) [13]. According to Das *et al.* [5], to diagnose FQRS on an ECG, certain characteristics must be present, such as an additional R wave (R'), notching at the base of the S wave, or several R's. Additionally, the QRS duration must be shorter than 120 ms, and the RSR' pattern must be present. In T wave inversion (TWI), the nadir is deeper than 0.1 mV and the waveform is inverted.

In addition, for every patient's ECG, we noted if there was a contiguous QWMI (cQWMI), a contiguous fragmented QRS (cFQRS), or a contiguous T wave inversion (cTWI). To use these nearby ECG markers (II-III-aVF, I-aVL, or V1-6; aVF = augmented Vector Foot, aVL = augmented Vector Left), at least two ECG leads from a significant coronary artery region were required.

2.1.1. DETERMINE Score and Selvester Score

To quantify the magnitude of an infarct, the modified Selvester QRS scoring system was created. It uses 37 ECG parameters to determine an overall score, which can vary from 0 to 29. We used the previously established criteria. Multivariate linear regression was utilized to see if CMR's MI % correlated with each ECG marker's lead number. In a study comparing the number of leads with QW to infarct size, the B coefficient was almost twice as high as the B coefficients for leads with FQRS and TWI. So, we came up with this formula: DETERMINE Score = [number of leads with QW (×2)] + [number of leads with FQRS] + [number of leads with TWI].

Magnetic Resonance Imaging: (patients underwent preoperative LGE-CMR imaging)

The CMR investigations utilized cine and long-grain echocardiography (LGE), which involved a short-axis stack and several long-axis images. The exclusion criteria for the investigations were the presence of image artifacts that hindered quantitative analysis or a short axis stack that did not encompass the whole left ventricle (LV) from the plane of the mitral valve to the apex. Quantitative analysis was conducted using QMass MR 7.5. The margins of the endocardium and epicardium were manually measured on cine short-axis images to determine the left ventricular ejection fraction (LVEF). The full width half max approach [14] was employed to quantify the infarct mass as a percentage of the total left ventricular myocardial mass (MI%) on late gadolinium enhancement (LGE) images.

CABG was performed on 100 patients with ICM who had a LVEF of 40% or less.: as in the **Figure 1** and **Figure 2**.

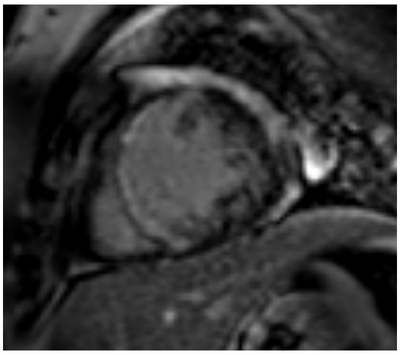

Figure 1. SAX LGE shows TM (transmural) fibrosis of apico-anterior and septal walls.

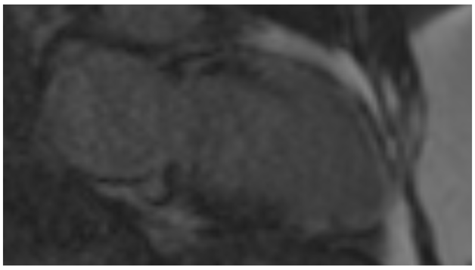

Figure 2. PSIR LGE 2CH shows TM (transmural) fibrosis involving basal to apical anterior walls.

2.1.2. Surgical Techniques

All CABG patients had a median sternotomy with left internal mammary artery (LIMA) to the left anterior descending (LAD) and great saphenous vein used for the rest of coronary arteries. The quality of the graft anastomosis was assessed using transit time flow measurements. Anastomosis was deemed nonfunctional if the pulse index was >5 and/or the mean graft flow was <10 mL/min [15] also assessment done with back flow or by heart function and clinical pattern of patients if flow meter does not present. For grafts that did not work, re-anastomosis was done until the results were adequate. All patients were on the typical anti-heart failure medication regimen following surgery.

The GDMT that was given to every single patient consisted of the following medications: antiplatelet agents, ARBs (angiotensin type II receptor blockers), beta blockers, mineral corticosteroid receptor antagonists, angiotensin receptor and neprilysin inhibitors & others [16].

2.1.3. Outcome Measures

- Primary Outcome: Correlation between DETERMINE Score and the severity of CAD.
- Secondary Outcome: MI segments and size were examined as predictors of cardiac function improvement after CABG.

2.1.4. Ethical Consideration

After approval of Local Ethics Committee, and informed written or verbal consents from all patients for surgery and coronary catheterization and PCI.

2.1.5. Statistical Analysis

The data that was collected was then evaluated using software & shown in tables or suitable graphs by computer software. Information gathered was input into the statistical package for the We used the social sciences (SPSS-20 Inc., Chicago, Illinois, USA for statistical analysis) software for further examination. While frequency was used to summarize qualitative data, descriptive data was organized in accordance with type, average, SD, & range for continuous data. We set the significant threshold at 0.05. We deemed results significant in statistics if the p-value was <0.05. Statistical factors were presented as the mean plus SD, whereas qualitative variables were presented as total number & ratio. Many statistical tests were used for the comparison, including the student "t" test, the Mann Whitney test, the chi-square test (X^2), the Z-test for percentage, & the odds ratio (OR).

3. Results

The flowchart of enrolled patients included diagnostic evaluations, interventions and outcomes demonstrated in Figure 3.

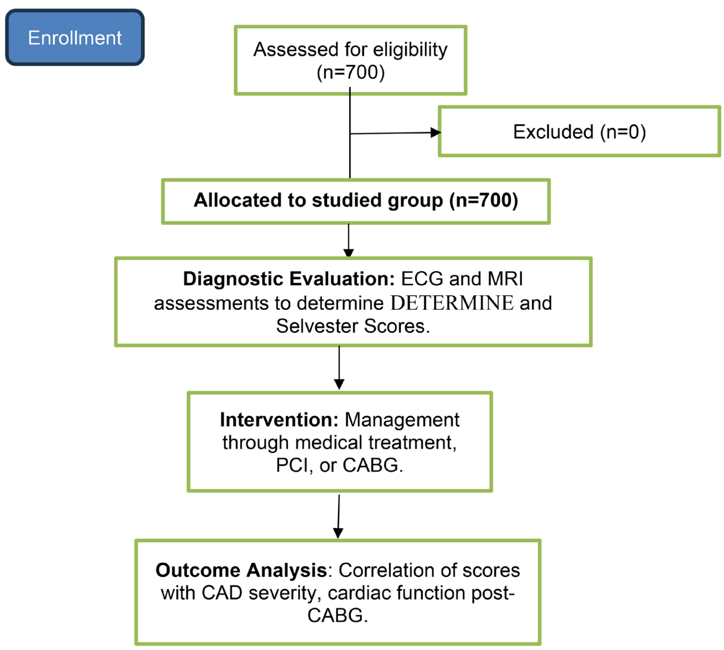

Figure 3. CONSORT flowchart of the enrolled patients.

There were 77% of patient's males and 23% of patient's females. The mean age of Studied people was 61.8 ± 11.57, mean Infarct size by CMR (%) was 15.67% ± 9.32% and mean Time from MI to ECG was 4.97 ± 6.76 and 15% of People were smokers as shown in Table 1 and Figure 4.

Table 1. Distribution of demographic characteristics of individuals studied.

	Studied group N = 700
Age **Mean ± SD**	61.8 ± 11.57
Gender	
Male	539 (77%)
Female	161 (23%)
BMI **Mean ± SD**	28.99 ± 8.27
Infarct size by CMR (%) **Mean ± SD**	15.67 ± 9.32%
Time from MI to ECG (year) **Mean ± SD**	4.97 ± 6.76
Current smoking (%)	105 (15%)

SD: Standard Deviation; BMI: body mass index; MI: myocardial infarction.

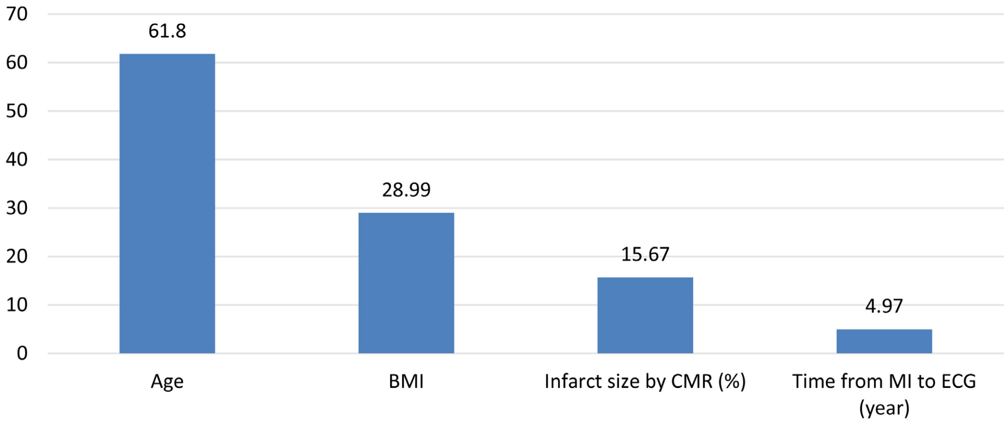

Figure 4. Distribution of patient characteristics.

Table 2. Distribution of comorbidity of studied patients.

	Studied group NO = 700
Peripheral vascular disease (%)	73 (10.42%)
Diabetes mellitus (%)	210 (30%)
Hypertension (%)	525 (75%)
Stroke (%)	42 (6%)

10.42% of patients had Peripheral vascular disease, 30% of patients had DM, 75% of patients had hypertension and 6% of patients had Stroke this data in Table 2.

Mean left ventricular ejection fraction was 39.85% ± 11.10%, mean Modified Selvester Score was 6.45 ± 4.54 & mean DETERMINE Score was 6.0 ± 4.71 as shown in Table 3 and Figure 5.

Table 3. Distribution of LVEF, DETERMINE score, and modified selvester score of studied patients.

	Studied group No. = 700
LVEF Mean ± SD	39.85% ± 11.10%
Modified Selvester Score Mean ± SD	6.45 ± 4.54
DETERMINE Score Mean ± SD	6.0 ± 4.71

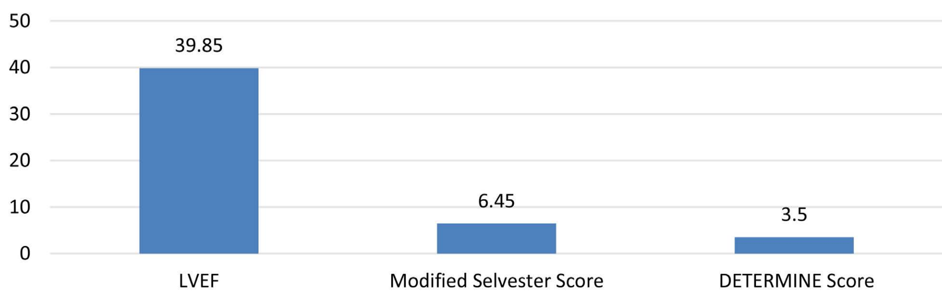

Figure 5. Distribution of LVEF, DETERMINE score & modified selvester score.

Table 4. Relation between infarct size and DETERMINE score of studied patients.

	DETERMINE Score				P value
	0 - 2 N = 175	3 - 5 N = 189	6 - 9 N = 195	≥10 N = 141	
infarct size Mean ± SD	11.15 ± 5.7	13.9 ± 7.86	17.86 ± 9.1	22.13 ± 8.9	≤0.001*

*Highly significant.

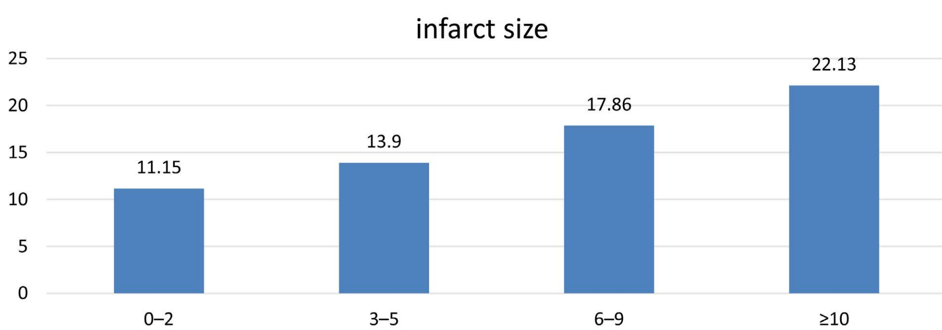

Figure 6. Distribution of infarct size in relation with DETERMINE score.

There was a highly statistically significant relation among Myocardial infarction size & DETERMINE Score as mean infarct size increased When the DETERMINE Score increased this data in Table 4 and Figure 6.

Mean myocardial infarction size increased with ECG Marker Score, which was highly statistically significant. As ECG markers increased as shown in Table 5 and Figure 7.

Table 5. Relation between infarct size and ECG marker score of studied patients.

	ECG Marker Score			
	No contiguous ECG markers N = 240	1 ECG markers N = 284	≥2 ECG markers N = 176	P value
infarct size Mean ± SD	10.98 ± 7.13	15.7 ± 8.5	21.11 ± 9.8	≤0.001*

*Highly significant.

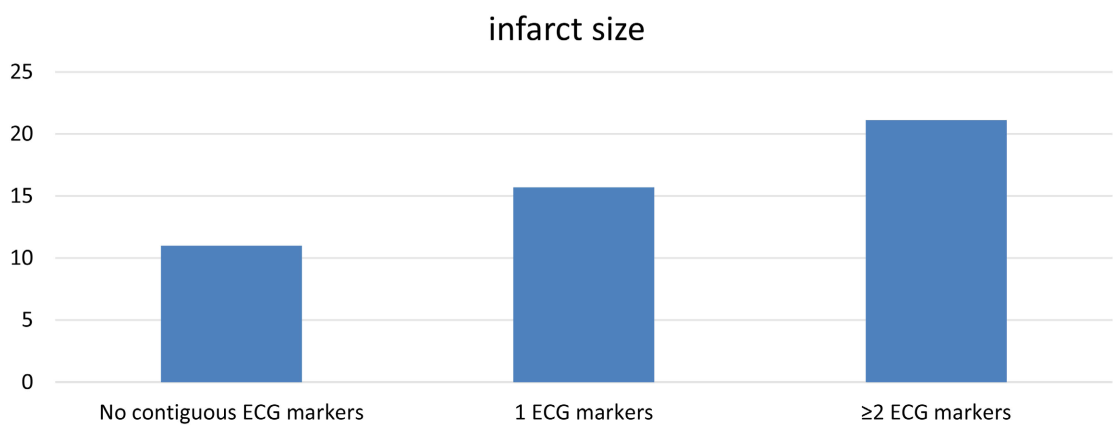

Figure 7. Distribution of infarct size in relation with ECG Marker Score.

14.28% of patients treated with CABG, 75.57% of people handled with PCI & others treated with medications as in Table 6.

Table 6. Distribution of management among studied patients.

	Studied group NO = 700
CABG %	100 (14.28%)
PCI	529 (75.57%)
medications	71 (10.14%)

There was highly statistically significant relation between myocardial infarct segments, myocardial infarction size and improvement of cardiac function 6 months post-CABG as shown in Table 7 and Figure 8.

Table 7. Relation between infarct size and improved cardiac function 6 months post-CABG of Studied Patients.

	improved cardiac function 6 months post-CABG N = 76	nonimproved cardiac function 6 months post-CABG N = 24	P value
myocardial infarct segments Mean ± SD	1.33 ± 2.23	4.33 ± 2.24	≤0.001*
myocardial infarct size Mean ± SD	12.34% ± 7.52%	28.57% ± 6.89%	≤0.001*

*Highly significant.

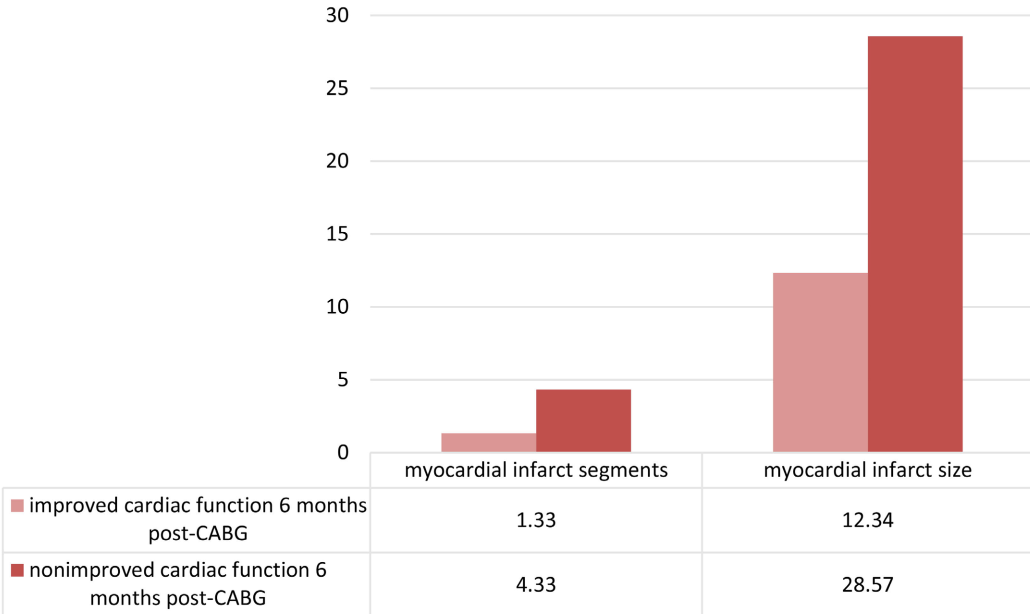

Figure 8. Distribution of infarct size in relation with improvement of cardiac function 6 months post-CABG.

4. Discussion

According to our knowledge there were limited studies investigated the role of Electrocardiogram DETERMINE Score in Prediction of CAD severity and thirty days' outcome in AMI people.

According to the findings of the current study, the mean Infarct size by CMR (%) was 15.67% ± 9.32% and mean Time from MI to ECG was 4.97 ± 6.76 and 15% of patients were smokers. The mean left ventricular ejection fraction was 39.85% ± 11.10%, mean Modified Selvester Score was 6.45 ± 4.54 and mean DETERMINE Score was 6.0 ± 4.71.

Also, our findings were in line with Lee *et al.*, [17] who evaluated whether In individuals who have had a previous myocardial infarction, aberrant ECG signals might be utilized to assess the extent of the infarct determined by CMR. They reported that 74 (13%) patients were smokers and the mean Infarct size by CMR

(%) was 5.7% ± 9.2% and mean time from MI to ECG was 5.4 ± 7.6 years. The mean LVEF was 40.3% ± 11.0%, the mean Modified Selvester Score was 6.6 ± 4.4 ranging from 0 to 26, and the mean DETERMINE Score was 6.0 ± 4.6.

Similarly, Chaudhry *et al.*, [18] evaluated ECG-based Selvester grading to evaluate myocardial scar load and predict clinical result. They reported that the mean left ventricular ejection fraction among there studied population was (LVEF) was 27.6% ± 11.7%.

A total of 57 electrocardiogram criteria are utilized in the process of assigning up to 32 points to the Original Selvester Score. Each point corresponds to an infarction of three percent of the left ventricle [16]. The Original Selvester Score predicts positron emission tomography infarct size better than QW or FQRS leads & corresponds with CMR infarct size (r = 0.40 - 0.43) in chronic MI people [19] [20].

This study demonstrated that Myocardial infarction size significantly increased when DETERMINE Score and number of ECG markers increased. Also, there was a significant association between myocardial infarct segments, myocardial infarction size and improvement of cardiac function 6 months post-CABG.

This study supported Lee *et al.* [17] who found that DETERMINE Score was substantially linked with MI size, with 2.6 points increasing MI size. Infarct size and the number of electrocardiogram markers (cQWMI, cFQRS, and cTWI) were shown to have a strong and continuous association with one another. Those individuals who had one ECG marker had a considerably larger infarct size, and those who had two or more ECG markers had an even larger infarct size.

CMR has allowed for the precise *in vivo* characterization of MI and comparison with ECG anomalies. Instead of focusing on the ECG's capacity to determine infarct size, most research has been single-center investigations that have defined the ECG's diagnostic accuracy [21].

According to previous investigations, ECG indicators and the Selvester score do not indicate infarct size when obtained acutely before discharge following reperfused MI [22] [23].

In line with our results, Zhao *et al.* [24] reported that 66.7% of the individuals they examined had improved cardiac function at the 6-month mark following CABG. The non-improved group had a higher number of myocardial infarct segments (median 4.0, IQR 3.0 - 6.0) compared to the improved group (median 1.0, IQR 0 - 3), with a statistically significant difference ($P < 0.001$). Additionally, the non-improved group had bigger infarcts (34.7% ± 5.9%) compared to the better group (22.4% ± 8.2%), with a statistically significant difference ($P < 0.001$). Doctors may utilize the researchers' discoveries to identify the patients who are more probable to have positive results following CABG. This can be achieved by assessing the amount of myocardial infarction, which serves as a dependable indicator of enhancements in heart function among individuals with ICM.

The study conducted by El-Shafey *et al.* [25] reported that people with an ejection fraction (EF) of less than 40% who undergo CABG often experience more complications in contrast to those with a mid-range or normal EF. However, CABG does lead to improved clinical outcomes and echocardiographic indicators of functional improvements. In addition, Aithoussa *et al.* [26] showed that obese individuals have a lower incidence of perioperative MI and a decreased requirement for inotropic medications or IABP, suggesting that obesity is not a risk factor for adverse outcomes following CABG.

5. Limitation

This work focused exclusively on individuals with a history of MI. Therefore, the evaluation of infarct size using electrocardiogram (ECG) markers may differ significantly in patients who have not experienced a previous MI. The findings of this study are solely applicable to the cohort of patients who were part of the trial. This cohort comprised persons diagnosed with coronary artery disease (CAD) who had experienced a previous myocardial infarction (MI) and/or had mild-to-moderate impairment in the function of their left ventricle (LVEF 35% - 50%). It is important to corroborate these findings in diverse communities.

6. Conclusions

The current study determined the role of Electrocardiogram DETERMINE Score in Prediction of coronary artery disease severity. We found that there was significant relation between Myocardial infarction size and DETERMINE Score as mean infarct size increased when the DETERMINE Score increased. Also, there was a significant association between myocardial infarct segments, myocardial infarction size and improvement of cardiac function 6 months post-CABG.

Our findings indicate that in individuals with a history of myocardial infarction (MI), a straightforward electrocardiogram (ECG) score can provide an estimated of the size of the infarct and enhance the accuracy of infarct size estimation compared to relying only on left ventricular ejection fraction (LVEF). The DETERMINE Score shows potential as a straightforward and cost-effective risk assessment tool due to the significant predictive value of infarct size.

Conflicts of Interest

The authors declare no conflict of interest related to this study.

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