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Assessment of the ST segment deviation area as a potential physiological marker of the acute myocardial infarction*

Laíse Oliveira Resende, Elmiro Santos Resende and Adriano O. Andrade

Abstract – **The purpose of this article is to present the assessment of the ST segment deviation area as a feature estimated from electrocardiographic signals to improve the current quantitative measures, which have low correlation with standard measures, such as biomarkers. In total 20 subjects were involved in the study. They were classified into two distinct groups (anterior and inferior) related to the localization of the acute myocardial infarction (AMI). The area of the ST segment was calculated by using customized software developed in Matlab®. From the analysis of this parameter it may be possible to correlate the ST deviation area with the necrosis risk area on myocardial tissue. The correlation between the ST area estimates were compared with Aldrich score, which uses the height of the J point instead of the area. It was calculated the correlation between the ST area, the Aldrich score and biomarkers of myocardial injury in patients. A Spearman correlation coefficient of 0.58 was estimated when comparing Aldrich score and the biomarkers for inferior AMI. The coefficient was 0.99 when correlating the biomarkers to the ST area. Therefore, this feature is a potential physiological marker of inferior AMI. The possibility of estimating the necrosis extent by means of electrocardiographic analysis allows for the reduction of cost and time since there may be no requirement for additional laboratorial exams, consequently improving the treatment efficacy and the prognosis of patients affected by acute myocardial infarction.**

Keywords – **acute myocardial infarction, score, electrocardiogram.**

I. Introduction

The Acute Myocardial Infarction (AMI) consists of myocardial necrosis from ischemia [1]. It is the occlusion of a coronary artery through lipid deposits and thrombosis, which interrupts blood supply to an area of the myocardium [2-4].

The heart receives blood through the coronary arteries and when a bunch of these sharply narrows or becomes blocked, inadequate circulation in the myocardial region supplied by this branch occurs [5]. The area of the infarcted heart, without blood supply, is electrically dead and cannot conduct electrical impulses [2].

Rapid diagnosis of AMI has great relevance, since it allows early treatment, increasing its efficiency. Due to easy use, low invasiveness, wide availability and low cost, the electrocardiogram (ECG) is one of the most important tools in clinical practice for the AMI diagnosis [3, 4]. Given the importance of rapid diagnosis, it might be desirable to make such diagnosis based on the ECG analysis, minimizing therefore the waiting time for its confirmation, usually obtained through molecular markers of myocardial injury, such as troponin T and creatine kinase (CK) and its isoenzyme CK-MB [6-9].

This has motivated the development of scores for quantifying the changes resulting from AMI based on the ST-segment elevation, which is the most common and visible change in the ECG related to AMI. The ST-segment elevation can be used to analyze the patient's prognosis, to estimate the area of AMI and in the assessment of reperfusion therapy [10, 11].

Among the available scores, the application of the Aldrich score [12] is considered to be a fast and simple procedure. For its estimate variables related to the ST-segment elevation are employed. Therefore, in this study it was selected as a tool for estimating the myocardial area at risk of necrosis.

It was observed in literature that there are several studies that compare this score with reliable measures of infarct size, validating it clinically. However, the statistical correlations obtained for AMI are low, varying from 0.4 to 0.6 [13-18]. For this reason, it is necessary to confront the Aldrich score with other measures so that it can be validated in clinical practice.

This study proposes a comparison between the ST segment deviation area and the biomarkers troponin T and CK-MB, because of limitations found in the current available scores.

It was also proposed a method for a more accurate estimate of the area at risk of myocardial necrosis with the aim of obtaining higher correlation with the biomarkers.

II. Methodology

This study was previously approved by the Ethics Committee of the Federal University of Uberlândia.

Data collection was carried out at the Clinical Hospital of the Federal University of Uberlândia (HCU / UFU). In total the electrocardiogram of 20 subjects affected by AMI were analyzed. The inclusion criteria required in this study were:

- Diagnosis of admission: anterior or inferior wall myocardial infarction;

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Laíse Oliveira Resende is a PhD candidate in the Laboratory of Biomedical Engineering, Faculty Electrical Engineering, Federal University of Uberlândia, Minas Gerais, Brazil (phone: +55 34 3239-4771; e-mail: laiseresende@yahoo.com.br).

Elmiro Santos Resende is medical doctor and professor in the Medical School of the Federal University of Uberlândia, Minas Gerais, Brazil (e-mail: eresende@cardiol.br).

Adriano O. Andrade is professor in the Faculty of Electrical Engineering, Federal University of Uberlândia, Minas Gerais, Brazil (e-mail: aoandrade@feelt.ufu.br).

- First ECG after the beginning of myocardial infarction: it should have been recorded in a maximum of eight hours after infarction, necessarily signaled by chest pain;
- Variations present in the ST segment of ECG: it was selected only patients whose ECGs contained significant ST-segment elevation (greater than 1 mm) in leads that indicate anterior or inferior infarction.

The selection of records was also based on complete block of any branch (left or right) or complete atrioventricular block.

All inclusion and exclusion criteria follow conventional guidelines for clinical studies with the Aldrich score [12].

In addition to the ECG records we also collected information regarding the age, gender, peak values of troponin T and CK-MB. It was also investigated whether there was previous infarction and heart failure.

Five out of 20 subjects suffered from anterior AMI, and they were male with mean age of 60.4 years. The other 15 subjects suffered from inferior AMI. The mean age of this group was 56.3 years and there were 12 male and 3 female participants.

The ECGs were divided into anterior and inferior AMI, according to the leads with ST-segment elevation. Subsequently, it was made the manual calculation of scores from the ECGs, considering the Aldrich score for anterior and inferior AMI. All these calculations were based on quantities of the ST segment, measured from the J point, which marks the junction between the end deflection of QRS and the beginning of segment ST (see Figure 1).

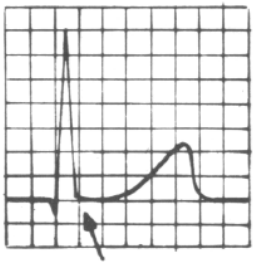

Figure 1. The normal ST segment. The arrow indicates the J point.

Equation (1) was used to calculate the score for anterior AMI and (2) for inferior AMI.

$$EA = 3[1{,}5\ (NDST \uparrow) - 0{,}4] \quad (1)$$

$$EA = 3[0{,}6\ (\sum ST \uparrow II, III, aVF\ ) + 2{,}0] \quad (2)$$

Where:

EA is the Aldrich score;

↑ NDST - Quantity of leads with ST-segment elevation;

↑ ST II - Height of ST-segment elevation calculated in the J point, in DII lead [mm];

ST ↑ III - Height of ST-segment elevation calculated in the J point, in DIII lead [mm];

ST ↑ aVF - Height of ST-segment elevation calculated in the J point, in aVF lead [mm].

The area of the ST segment deviation with the inclusion of T wave was calculated by a customized program developed in MatLab®.

The trapezoidal method available in Matlab (trapz) was used to compute the integral and obtain the area under the curve. The integral boundaries are defined by the beginning of the ST-segment deviation, which is J point, and the end of the ST-segment elevation with the inclusion of T wave.

The Spearman correlation coefficient was used for statistical analysis because the non-normal distribution of data, verified by the Shapiro-Wilk test and Kolmogorov-Smirnov test. The correlations were calculated in the Statistica® software (StatSoft).

III. Results

The Spearman correlation coefficient, for the anterior AMI group, is given in Table 1. There is a high correlation between Aldrich score and troponin T (TnT) ($r_s = 0.89$) with *p*-value equal to 0.02. In contrast, the correlation with the CK-MB was not statistically significant ($r_s = 0.67$; *p*-value = 0.11).

TABLE 1 – CORRELATION BETWEEN ALDRICH SCORE, TNT AND CK-MB (ANTERIOR AMI).

		Aldrich score
TnT	**r_s**	0.89
	n	5
	***p*-value**	0.02
CK-MB	**r_s**	0.67
	n	5
	***p*-value**	0.11

r_s - Spearman correlation coefficient.

Table 2 shows the correlation coefficient, for the anterior AMI group, between the ST segment deviation area and the biomarkers (TnT and CK-MB). Note that it was estimated the mean of the areas obtained for each electrocardiographic lead.

It can be observed from Table 2 that the value of areas was not significant (*p*-value < 0.05) for this type of infarction.

TABLE 2 – CORRELATION BETWEEN MEAN AREA, TNT AND CK-MB (ANTERIOR AMI).

		TnT	CK-MB
Mean area	r_s	0.60	0.70
	n	5	5
	p-value	0.14	0.09

Table 3 shows the correlation coefficient, for the inferior AMI group, estimated from the correlation between the Aldrich score and the biomarkers (TnT and CK-MB).

According to the results presented in the table, the correlation coefficient between the Aldrich score for inferior AMI, which considers the sum of the heights at the J point in DII, DIII and aVF, and TnT was $r_s = 0.59$ and CK-MB was $r_s = 0.52$.

TABLE 3 – CORRELATION BETWEEN ALDRICH SCORE AND TNT AND CK-MB (INFERIOR AMI).

		Aldrich score
TnT	r_s	0.59
	n	15
	p-value	0.02
CK-MB	r_s	0.52
	n	15
	p-value	0.02

In addition, it was calculated the Spearman correlation coefficient for the analysis of the correlation between the mean area of the ST-segment elevation and biomarkers. As observed in Table 4, the correlation obtained was very high ($r_s = 0.99$).

TABLE 4 – CORRELATION BETWEEN MEAN AREA AND TNT AND CK-MB (INFERIOR AMI).

		TnT	CK-MB
Mean area	r_s	0.99	0.88
	n	15	15
	p-value	<0.0001	<0.0001

IV. DISCUSSION

As shown in Tables of 1 to 4, the results obtained for the correlation between the Aldrich score and biomarkers of myocardial injury for anterior AMI were higher than the area of ST segment deviation. The Aldrich score showed high correlation with troponin T ($r_s = 0.89$), but the correlation with CK-MB was not significant. However, for the areas, the values obtained were not significant.

This fact can be explained by the location of the anterior infarction. There is juxtaposition of walls and how it has the opposite direction to the interventricular septum, there will be opposing vectors, generating possible record low J point amplitude and a small area, despite a large area of myocardial infarction [13-15].

Thus, the magnitude of the ST segment would not be important, but the number of leads with ST segment elevation, as indicated by the equation of Aldrich score for anterior AMI. Therefore, the proposed method is not useful for anterior infarction.

However, for the subjects with inferior AMI, the new score with the area of ST segment deviation indicates a higher correlation with troponin T and CK-MB than the Aldrich score (which uses the sum of the amplitudes calculated in J point in leads DII, DIII and aVF). Therefore, according to this analysis, the area demonstrates more consistently the area at risk of necrosis, while Aldrich score has lower correlation for inferior AMI. The correlation coefficient of the Aldrich score with the biomarkers was approximately 0.5. The correlation coefficient between the ST area and the biomarkers was around 0.9.

For the ST segment deviation area, we obtained a high correlation between the mean areas and troponin T ($r_s = 0.99$). The results show that normally the correlation was higher for the troponin T, which is considered a more specific marker to detect myocardial injury [3].

V. CONCLUSION

The main aim of the study was to assess the correlation of ST segment deviation area with the biomarkers, and to verify whether this feature (i.e., area) could be a potential physiological marker of the acute myocardial infarction.

The results suggested a high correlation between the ST area and the biomarkers for inferior AMI, showing therefore that the proposed method (i.e., the analysis of the area) is more suitable than the Aldrich score.

The results from this study may be used for the development of a prediction model of the area at risk of myocardial necrosis, as a complementary diagnostic tool, which is independent from the results of biomarkers that would only be available after 4 to 6 hours after precordial pain.

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