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# Inter-Rater Reliability of ST-Segment Measurement at a University Hospital in Argentina

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**Abstract:** The accurate determination of the electrocardiographic ST-segment elevation in a patient with clinical suspicion of acute coronary syndrome is essential for treatment with urgent myocardial reperfusion. The aim of this study was to determine the inter-rater reliability of ischemic and non-ischemic ST-segment elevation measurement among physicians with different specialties and experience. We performed an observational, cross-sectional study, with a comparative correlation and paired sampling. 56 physicians from a university hospital in Buenos Aires city were included: Cardiologists from the Coronary Care Unit (CCU) and Cardiology Division, Internal Medicine physicians from the hospitalization, ambulatory care and Emergency divisions, and third- and fourth-year Internal Medicine residents. Each participant analyzed 6 electrocardiograms and was asked to determine the magnitude of the ST-segment elevation at the J-point, and the corresponding diagnosis. The inter-rater coefficient was lower than 0.2, and the global kappa coefficient was 0.06 ( $p < 0.001$ ). The global correct interpretations were: inferior wall myocardial infarction (MI): 89.3%; anterior wall MI: 51.8%; lateral wall MI: 75%; left bundle branch block: 91.1%; left ventricle hypertrophy: 44.6%; acute pericarditis: 25%. We believe that the low correlation was probably due to the difficulty in determining the J-point. These findings could suggest the need to strengthen the electrocardiographic concepts of ischemia, and the differentiation between ischemic and non-ischemic ST-segment elevations.

**Keywords:** J Point, Electrocardiogram, Ischemia, Infarct, ST Segment

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## 1. Introduction

The precise determination of an ST-segment elevation, on the electrocardiogram of a patient in whom an acute coronary syndrome is suspected, is the key to correctly applying the electrocardiographic criteria for urgent myocardial reperfusion. According to the fourth definition of acute myocardial infarction [1] and the guidelines from the *American Heart Association* [2], a diagnostic ST-segment elevation is defined as the elevation of the J point in, at least, two adjacent leads  $\geq 1$ mm in all leads other than V2-V3, where the cutting point is  $\geq 2$  mm in men older than 40 years,  $\geq 2.5$  mm in men under 40 years, and  $\geq 1.5$  mm in women regardless of age. The American Heart Association defined these findings as class I and “A” level of evidence for urgent myocardial reperfusion on the appropriate clinical context.

Despite these specific criteria, it has not been defined

where nor how to measure the ST-segment elevation [3]. Some researchers have used the J-point, while others used a 60 or 80 msec distance from the J-point [3-5]. Research conducted at Emergency Departments have reported between 1.9 and 8% of all patients who attend because of chest pain caused by acute myocardial infarction are mistakenly discharged with an incorrect diagnosis, probably due to overlooking the ST-segment elevation [6]. On the other hand, QRS repolarization abnormalities may be responsible for STEMI false-positives, therefore limiting the usefulness of ECG as a sole diagnostic tool [7].

The general objective of this work was to determine the inter-rater reliability between physicians of different specialties and expertise in determining the ST-segment elevation due to ischemic and non-ischemic causes, and in establishing an electrocardiographic diagnosis.

## 2. Materials and Methods

We designed a cross-sectional, observational, comparative correlational study, using paired samples. The following physicians from a University Hospital from Buenos Aires, Argentina, were enrolled: 1) Cardiologists from the Cardiovascular Intensive Care Unit and Cardiology Division, 2) Clinicians who work in the Internal Medicine Department and Ambulatory Care division, 3) third- and fourth-year Internal Medicine Residents, and 4) Internists who work in the Emergency Department. Written authorization from each chief of Department and from the Bioethics Committee was obtained. This protocol was conducted according to the Declaration of Helsinki. Data collection was carried out from October 23<sup>rd</sup> to December 31<sup>st</sup>, 2015.

Each participant was requested to analyze 6 electrocardiograms, which were obtained from the website *CardioNetworks* (<http://www.cardionetworks.org>) and *Life In the Fast Lane* (<http://lifeinthefastlane.com>). They are Open Access, according to each website's declaration. The following diagnoses were included: *Anterior acute myocardial infarction (MI), acute pericarditis, left bundle branch block, lateral acute MI, left ventricle hypertrophy, inferior acute MI*. They were exhibited on A4 size paper, and for each of them, through a questionnaire, the participants were requested to determine the magnitude in millimeters of the ST-segment elevation at the J-point, and the electrocardiographic diagnosis. No clinical data was provided for the cases, permitting the participants to concentrate solely on the electrocardiograms. The identity of both the patients to whom the electrocardiograms belong and that of the participants was preserved.

The intraclass correlation coefficient was determined for each observation, and for each previously defined subgroup.

Kappa coefficient was calculated to determine the global correlation between the participants. In order to compare the percentage values, the chi-square test was used. A statistical significance level of 0.05 was established. The statistic software used was Stata 12.0.

## 3. Results

We analyzed data obtained from 56 physicians. 44.64% were Clinicians, 19.64% were Cardiologists, 26.79% were fourth-year Internal Medicine residents, and 8.93% were third-year Internal Medicine residents. 58.18% of the participants performed their activities on critical areas, such as the CCU and the Emergency Department.

Intraclass correlation coefficient according to specialty was lower than 0.2, with no statistical significance. Global kappa coefficient was 0.006 ( $p < 0.001$ ).

Global successful diagnostic percentages for each ECG presenting an ischemic ST-elevation cause were: inferior wall MI: 89.3%, anterior wall MI: 51.8%; lateral wall MI: 75%. For the remaining diagnosis, results were: left-bundle branch block: 91.1%; left ventricle hypertrophy: 44.6%; acute pericarditis: 25%. Regarding the latter electrocardiogram, 30% of participants informed the alternative diagnosis of early repolarization, ventricular extrasystoles, left bundle branch block, among others. In more than half of the cases (55.4%), left ventricle hypertrophy was mistaken for left ventricle overload, lateral wall MI and inferior wall MI.

During analysis by medical specialty, we found the greatest percentage of correct diagnoses was among Cardiologists, as stated in table 1. For lateral wall diagnosis, the difference between Cardiologist and Clinicians was statistically significant ( $p = 0.045$ ).

**Table 1.** Correct electrocardiographic diagnosis according to specialty [%].

	Cardiologists	Clinicians	4 <sup>th</sup> year residents	3 <sup>rd</sup> year residents	p
Anterior wall MI	81.82	56	26.67	40	0.040
Lateral wall MI	100	72	60	80	0.13
Inferior wall MI	100	100	66.67	80	0.004
Acute pericarditis	63.64	20	13.33	0	0.006
Left-bundle branch block	90.91	84	100	100	0.33
Left ventricle hypertrophy	54.55	40	40	60	0.7

As for correct diagnoses according to seniority in the medical practice, tendency to provide correct answers was greater in those physicians with over 5 years of experience, especially among electrocardiograms with signs of ischemia. Data is presented in table 2.

**Table 2.** Correct electrocardiographic diagnosis according to experience [%].

	Over 5 years	Less than 5 years	p
Anterior wall MI	66.67	38.71	0.040
Lateral wall MI	75	74.19	0.946
Inferior wall MI	100	80.65	0.022
Acute pericarditis	29.17	19.35	0.396
Left-bundle branch block	83.33	96.77	0.086
Left ventricle hypertrophy	41.67	45.16	0.796

Finally, after comparing answers from physicians belonging to critical care units to those who work at non-critical units, there were no statistically significant differences (table 3).

**Table 3.** Correct electrocardiographic diagnosis comparing critical-care units and non-critical care units [%].

	Critical care units	Non-critical care units	p
Anterior wall MI	47.83	54.55	0.698
Lateral wall MI	82.61	69.70	0.244
Inferior wall MI	95.65	84.85	0.186
Acute pericarditis	34.78	18.18	0.099
Left-bundle branch block	86.96	93.94	0.387
Left ventricle hypertrophy	30.43	54.55	0.094

## 4. Discussion

As already mentioned, the recently published Fourth Definition of Myocardial Infarction clearly establishes the criteria a J point elevation must meet [1]. Nevertheless, determining the J point can be difficult due to preexisting or ischemia-induced conduction disturbances or early repolarization [8].

A Multidisciplinary Standardized Reporting Criteria Task Force recommends using the TP-segment as a reference for the isoelectric baseline (unless tachycardia or artifacts preclude this measurement) and measuring ST-segment elevation 0.06 seconds from the J point [9]. The lack of a universalized practice when determine the ST-segment elevation is probably responsible for the inter-rater variance, which has been addressed in reduced groups and among experienced Emergency Medicine physicians.

A case-control study conducted in The Netherlands [8] analyzed 53 ECGs recorded preceding emergency catheterization of acute coronary syndrome patients with a completely occluded culprit artery and 88 control elective ECGs recorded in the cardiology outpatient clinic, using a software (LEADS) which performs baseline corrections, calculates an averaged beat and computes global onset-Q, J-point and end-of-T landmarks. The authors obtained the highest sensibility and specificity (94.3 and 93.2% respectively) for ST-elevation myocardial infarction (STEMI) when ST-elevation was measured 10 msec after the J-point.

Our study resulted in a much lower inter-rater reliability than others. Lim et al. [3] recruited 30 physicians from an Emergency Department in Singapur, including 6 consultant Emergency physicians, 2 senior Emergency Medicine residents, and 22 physicians trained in specialties different from Emergency Medicine. They found an excellent level of agreement among physicians from different specialties (intraclass correlation coefficient= 0.85), but no comparison between experienced and less-experienced physicians could be made because the number of the former was small. Erling et al. [6] found the smallest the ST-segment elevation, the greater the discordance rate among experienced Emergency physicians: no discordance when ST-segment elevation was over 10 mm (kappa coefficient= 1), and significant discordance when ST-segment elevation was less than 5 mm (kappa coefficient= 0.48). It has also been described ST-segment elevation magnitude differs according to whether it is determined at the J point, or 60 milliseconds after it: in the first case, less patients with retrospective diagnosis of MI

fulfilled criteria for ST-segment elevation [10]. A different study compared inter-rater variability between 20 Emergency physicians, 20 Emergency Medicine residents and 20 fourth-year Medicine students (60 participants in all), analyzing 2,070 ST-segments. There were no statistically significant differences using 2 mm diagnostic criteria [11]. We cannot determine whether this difference between this study and our results lies in the participant's performance, or in the fact that the former was based on a much greater electrocardiogram/participant ratio than ours. Lastly, McCabe, et al. [10] conducted a cross-sectional survey among 124 physicians (Emergency Physicians, Cardiologists and Interventional Cardiologists), consisting of 36 deidentified ECGs that had previously resulted in putative STEMI diagnoses (the reference standard for STEMI diagnosis was subsequent emergent coronary arteriography). Participants were asked the following: "Based on the ECG above, is there a blocked coronary artery present causing a STEMI?". Inter-reader agreement (kappa) for ECG interpretation was 0.33. The sensitivity to identify real STEMI was 65% and specificity was 79%. They found no significant difference by specialty. An Italian research group and the Italian Society of Emergency Medicine (SIMEU) reproduced the same survey three years later and determined an 85.2% positive predictive value of a STEMI interpretation among all readers, and a 52.8% negative predictive value. Overall accuracy (the ability to discriminate true STEMI pattern from false STEMI electrocardiographic changes) was 69.1%. The authors concluded ECG interpretation lacks the necessary sensitivity and specificity to be considered a reliable single diagnostic test [13].

To further complicate matters, there are non-ischemic causes of ST-segment elevation. These patients, despite fulfilling the already mentioned criteria from the *American Heart Association* [2], should not be subjected to urgent myocardial reperfusion. A study conducted by Brady, et al. [13] at a University Hospital tested the determination of ST-segment elevation at the J-point and its etiology on experienced Emergency physicians, retrospectively comparing it to Cardiologists who had evaluated patients with chest pain. They concluded that the performance of Emergency Physicians was: acute pericarditis: 100%; left bundle branch block: 97%; left ventricle hypertrophy: 96%, among other diagnoses we did not include. These results differ from ours, compared to those obtained in the Critical Care Unit subgroup (34.78%, 86.96% and 30.43% respectively). It is important to highlight the statistically significant difference obtained between the diagnosis of anterior and inferior wall MI, both according to specialty and

experience. Regarding early repolarization, an electrocardiographic pattern which may mimic an ischemic ST-segment elevation, a different study observed it was correctly interpreted by 90% of cardiologists and 81% of Emergency physicians. Moreover, overdiagnosis (that is, incorrect diagnosis of MI rather than early repolarization) was greater in the Emergency physician group (27.6%) than in the Cardiologist group (17.3%). Underdiagnosis (mistaken diagnosis of early repolarization over MI) was lower in the Cardiologist group (2.8% against 9.7%). All differences were statistically significant [15]. We must remember the participants of our study were not provided with the medical records of the patients whose electrocardiograms were analyzed. Even though this lack might have conditioned to some extent the electrocardiographic diagnosis, we do not believe it accounts for the inter-rater variability of the J-point elevation since this is an objective determination.

## 5. Conclusion

In this study, we found a low inter-rater correlation in determining the ST-segment elevation at the J point, evidencing a difficulty in establishing the latter. Moreover, the percentage of correct answers for each electrocardiographic diagnosis was variable, both within each specialty and between them. Experienced cardiologist had the most ability to establish a correct diagnosis. This could imply the need to strengthen, especially among trainee-physicians, the electrocardiographic signs of ischemia, and to differentiate ischemic and non-ischemic causes of ST-segment elevation.

## Conflict of Interest

None to declare.

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