The Dependence of the STEMI Classification on the Position of ST-deviation Measurement Instant Relative to the J point

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Abstract

Introduction. The electrocardiogram (ECG) is an important diagnostic tool in acute coronary syndrome (ACS). STEMI (ST Elevation Myocardial Infarction) is formally diagnosed by ST-deviations measured at the J point. However, due to uncertainty about the position and amplitude of the J point, ST deviations are often measured at a fixed-time interval after the J point. The impact of the position of the ST-deviation measurement on STEMI classification is not known and is the subject of the current study.

Methods. ECGs of 53 ACS patients (13/40 females/males, mean \pm SD age 59.6 \pm 14.9 years) with a completely occluded culprit artery found by catheterization were analyzed. ST deviations were measured every 10 ms between 20 ms before till 80 ms after the J point and percentages STEMI classified ECGs were calculated for four different cumulative STEMI groups.

Results. STEMI diagnosis was quite stable between 10 and 40 ms after the J point. Only when measured at 70 or 80ms after the J point and applying the most liberal cumulative STEMI group all ECGs were classified as STEMI.

Discussion & conclusion. ST-deviation measurement between 10 and 40 ms after the J point yields stable results for all cumulative STEMI groups. Further investigation including ACS-negative ECGs is needed to investigate the trade-off between false-positives and falsenegatives STEMI classified ECGs.

1. Introduction

Chest pain is a subjective symptom and can be caused by many other conditions than acute coronary syndrome (ACS). It is, however, the trigger for an emergency call by the patient. At first medical contact, when the working diagnosis of ACS is to be accepted or rejected, the electrocardiogram (ECG) is the only objective diagnostic tool available (serum biomarkers increase only after necrosis has occurred [1]).

According to the guidelines, ACS ECGs are classified

as either ST-elevation / ST-elevation equivalent myocardial infarction (STEMI) or as non-ST-elevation myocardial infarction (NSTEMI). This bisection determines whether percutaneous coronary intervention (PCI) is indicated as initial therapy or not. STEMI is established by using ST-deviation measurements at the J point [2,3].

The J point is defined as the time when an ECG tracing changes slope abruptly at the end of the S wave. In a 12lead ECG, theoretically, 12 different lead-dependent J points could be identified; the global J point is the latest of the lead-dependent J points. In practice, determination of the J point is difficult in standard 12-lead ECG view, because this does not facilitate easy visual determination of the latest of lead-dependent J points. Rather, an aligned display of the ECG leads, like in Figures 1 or 2, is needed.



Figure 1. Superimposed view of a 12-lead ECG from our ECG analysis software LEADS[6] used to establish the J point. The black vertical lines are from left to right: onset Q, J point and T end.

However, even with such tools, it is still difficult to determine the J point like in an ischemic ECG as displayed in Figure 3. In ischemic ECGs, the localization of the J-point is often obscured by ischemia-induced conduction delays and/or ischemia-induced early repolarization. ST-deviation measurements at a fixed time-interval (40, 60 or 80 ms) after the J point is one of the often-suggested solutions to obtain a more stable measurement [4,5]. However, the impact of the position

in time of the ST-deviation measurement on the actual STEMI classification is not known. Therefore, in our current study, we investigated how STEMI classification in ACS ECGs depends on the position of ST-deviation measurement relative to the J point.



Figure 2. Cabrera display of the same patient as in Figure 1. Note that the 6 limb leads of the ECG are ordered according to a hexaxial reference system, implying inversion of lead aVR.



Figure 3. Superimposed averaged beat view of a 12-lead ischemic ECG. In this ECG, the J point cannot be determined with certainty. The black vertical lines are from left to right: onset Q, J point and T end.

2. Methods

We analyzed standard 12-lead ECGs of 53 ACS patients, as described in an earlier study [7]. All ECGs preceded primary PCI. Al patients had a completely occluded culprit artery during angiography. When more than one ECG preceding PCI was available, the ECG closest in time with respect to PCI was selected. ECGs were analyzed by using our LEADS program[6]. In short, LEADS performs baseline correction, calculates an averaged beat and computes default onset Q, J point and the end of the T wave landmarks, to be interactively reviewed and when necessary edited by the LEADS

analist. J points were determined by a panel of observers consisting of 2 cardiologist experts and 2 researchers during an interactive LEADS session with online screen sharing [7]. Then, ST deviations were measured in all leads, every 10 ms, between 20 ms before till 80 ms after the J point.

At each measurement instant, the following decision logic was used to characterize the ST deviations. An ECG amplitude was classified as elevation when ≥ 0.1 mV in any lead, except for leads V2 and V3, in which the threshold was 0.2 mV. An ECG amplitude was classified as depression when ≤ -0.1 mV in any lead, except for leads V2 and V3, in which the threshold was -0.05 mV. Four STEMI subgroups were used:

- "STEMI strict": two adjacent limb or precordial leads show ST elevation;
- "STEMI extended": including inverted lead III and aVL;
- "STEMI equivalent": leads V2 and V3 show ST depression;
- "STEMI equivalent extended": two adjacent leads among the limb leads, the precordial leads and the inverted leads III and aVL show ST depression

Subsequently, these four STEMI subgroups were combined to four cumulative STEMI groups in a specific order:

- 1. STEMI strict
- 2. STEMI strict + STEMI equivalent
- 3. STEMI extended + STEMI equivalent
- STEMI extended + STEMI equivalent extended ("24-lead ECG")

In this cumulative grouping system, in which each higher group includes all ECGs of the lower group, the STEMI strict group is the most restrictive and the STEMI extended + STEMI equivalent extended is the most liberal. Subsequently, for each ST deviation measurement relative to the J point, each ECG was classified into the appropriate STEMI subgroup and cumulative group. Finally, the percentages STEMI-classified ECGs in the cumulative groups were computed for each of the STdeviation measurements.

3. Results

The study group consisted of 53 ACS patients, 13/40 females/males and with mean \pm SD age of 59.6 \pm 14.9 years. Table 1 and Figure 4 shows per ST deviation measurement the percentages STEMI classified ECGs. The most strict and liberal cumulative groups (1 and 4) showed a large difference in the percentages STEMI-classified ECGs, especially at and before the J point. Steady performance in all cumulative groups were seen between 10 and 40 ms after the J point.

Measurement instant relative to J (ms)	STEMI strict	STEMI strict + STEMI equivalent	STEMI extended + STEMI equivalent	STEMI extended + STEMI equivalent extended
-10	66	75	85	89
0	79	85	92	96
10	83	89	92	94
20	83	87	91	92
30	85	89	94	96
40	85	89	94	96
50	89	92	94	96
60	91	94	96	98
70	91	92	98	100
80	98	98	100	100

Table 1. Percentages STEMI classified ECGs in the

cumulative groups per ST deviation measurement.



Figure 5. Pictorial representation of Table 1. Percentages STEMI classified ECGs for each of the ST deviation measurement instants are shown for all cumulative STEMI groups (magenta: cumulative group 1; green: cumulative group 2; blue: cumulative group 3; black: cumulative group 4).

3.1. Examples

The first example is a male ACS patient of 54 years old. The ECG (see Figure 6) shows ST elevations in leads I, aVL, V1-V5, and ST depressions in leads II, III, aVF. Figure 7 depicts the J point (106 ms after onset Q) in the averaged beat view. In this case, the ECG was classified as STEMI in all cumulative groups and for all ST- deviation measurement instants.



Figure 6. ECG of ACS patient #29. Blue squares: ST elevations in lead I, aVL, V1-V5. Black squares: ST depressions in lead II, III, aVF.



Figure 7. Averaged beat view of the ECG of ACS patient #29. The black vertical lines are from left to right: onset Q, J point and T end.

The second example is a female ACS patient of 42 years old. Her ECG (see Figure 8) shows ST elevations in leads III and aVF, and ST depressions in leads I and aVL.



Figure 8. ECG of ACS patient #15. Blue squares show ST elevations in leads III & aVF, and black squares show ST depressions in leads I and aVL.

Figure 9 depicts the J point (90 ms after onset Q) in the averaged beat view. For ST deviations measured at either 20 ms before the J point or between 50 and 80 ms after the J point, the ECG was classified as STEMI in all cumulative groups. Contrastingly, for ST deviations measured at either 10 or 20 ms after the J point, the ECG was not classified as STEMI in any of cumulative groups.



Figure 9. Averaged beat view of the ECG of ACS patient #15. The black vertical lines are from left to right: onset Q, J point and T end.

5. Discussion and conclusion

In this study, the dependence of the STEMI classification on the position of ST-deviation measurement instant relative to the J point was investigated in the ECGs of 53 ACS patients. All patients had a completely occluded culprit artery. However, not all ECGs met the STEMI criteria, even not the most liberal ones. For instance, in the second example patient #15, the criteria for ST elevation in lead aVF, 100 μ V, was not met for ST deviation measurements made at 10 and 20 ms after the J point.

In our study, the range of measurement instants relative to the J point (-20 to +80 ms) was chosen in such a way that the earliest measurements were in the QRS complex and the latest measurements were in the T wave. According to our results, early measurement have the risk of missing a number of ACS cases and late measurements seem to yield the best result (see Table 1 and Figure 5). However, late measurements, obviously in the T wave, will be aspecific and are likely to yield false-positive STEMI classification in ACS-negative control ECGs. Such ECGs should be included in a next study.

Most likely, measurements done between 10 and 40 ms after the J point, possibly 40 ms after the J point will yield optimal results, however, this is still to be demonstrated in a study that includes ACS-negative control ECGs.

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