New electrocardiographic diagnostic criteria for the pathologic R waves in leads V1 and V2 of anatomically lateral myocardial infarction

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Abstract

Aims: To study the different QRS patterns in leads V1 and V2 in first inferior, lateral, and combined inferolateral myocardial infarction (MI) to recognize which are the ECG criteria that best define the presence of lesions isolated to the anatomically lateral wall of the left ventricle.

Methods and results: We studied consecutive patients with first inferior (15), lateral (9), or inferolateral (21) MI with reference to contrast enhanced cardiac magnetic resonance (CE-CRM). We measured the R-wave amplitude and duration, the R/S ratio, and the T-wave amplitude and polarity in leads V1 and V2. The specificity of the V1 criteria for lateral MI, that is, R/S amplitude ratio 1 or greater and R duration 40 milliseconds or longer, is very high but its sensitivity is low. We defined 2 new criteria, R/S of 0.5 or greater and R amplitude in V1 greater than 3 mm, with each achieving a sensitivity of 73.3% and specificity of 93.3% for lateral/inferolateral MI location.

Conclusions: (1) New ECG criteria for lateral MI (R/S ratio in V1 ≥ 0.5 and R amplitude in V1 > 3 mm) present very high specificity and lower but very acceptable sensitivity for lateral MI. (2) New criteria based on R waves in V2 or T waves in V1 to V2 do not discriminate between inferior and lateral MI. (3) The classical criteria (R/S amplitude ratio ≥ 1 and R duration ≥ 40 ms in V1) attain very high specificity but much lower sensitivity than the new criteria.

Keywords: ECG criteria; Contrast-enhanced cardiovascular magnetic resonance; Myocardial infarction location

Introduction

In 1964, Perloff published “The Recognition of Strictly Posterior Myocardial Infarction by Conventional Scalar Electrocardiography”. The involved region was considered to be in the basal portion of the left ventricular (LV) inferior wall, and the term posterior seemed appropriate because the cardiac orientation was assumed from pathologists’ ex vivo conception as presented in Fig. 1A. 2 The infarction vector of the “posterior wall” would face the positive poles of leads V1 and V2 producing “Q-wave equivalent,” pathologically increased R waves. Since then, R/S amplitude ratio of 1 or greater and R-wave duration of 40 milliseconds or longer in lead V1 have emerged as the most accepted diagnostic criteria for posterior MI. 3–5

In the 1970s, Selvester et al 6 and Ideker et al 7 studied the relationships among the angiographic/ventriculographic, postmortem anatomic, and electrocardiographic manifestations of human myocardial infarction. They found that occlusion of a nondominant left circumflex coronary artery resulted in ventriculographic dysfunction and anatomic fibrosis of the LV free wall directly opposite to the interventricular septum and represented on ECG by the QRS changes typical of “posterior” MI location. 8 As this LV region was only visible on the left anterior oblique view of the biplane ventriculogram, they applied the term posterolateral (Fig. 1B and C). Anderson et al 9 retained the term posterior for the 8 QRS scoring criteria in leads V1 and V2
for estimating infarction of as much as 24% of the LV, which included the screening criterion of V1 R duration of 40 milliseconds or longer.

Contrast enhanced-cardiac magnetic resonance (CE-CMR) provides the direct infarct imaging required to confirm anatomic and electrocardiographic relationships, and its developers have adopted the terminology of walls of the LV in agreement with the North American Society of Cardiac Imaging (NASCI): anterior, septal, inferior, and lateral (Fig. 2). Bayés de Luna et al. have used reference to CE-CMR to demonstrate that the infarction vector of isolated "inferior wall" MI faces leads V3-V4 and does not therefore generate pathologic R waves in V1-V2 (Fig. 1B). However, the infarction vector of isolated "lateral wall" MI does face leads V1-V2 and therefore generates the pathologic R waves that have earlier been termed posterior (Fig. 1C). Bayés de Luna organized an international group that reached the consensus that the electrocardiographic term posterior should be suppressed and replaced by the NASCI-accepted term lateral to designate infarction of this region in the LV free wall.

The aim of the present work was to study the different QRS patterns in the precordial leads V1-V2, in cases of first isolated inferior, isolated lateral, and combined inferolateral MI according to this new classification based on reference to CMR to define the ECG criteria that could locate the involved region with the highest possible accuracy.

Methods

Study participants

A total of 45 consecutive patients (38 male, 7 female) (mean age 60 years) with first ST elevation–acute coronary syndrome (STE-ACS) evolving to CE-MRI documented infarction in the isolated inferior, lateral, or combined...
inferolateral LV walls were studied from May 2005 to April 2006. Those with a history of other cardiac disease or chronic obstructive pulmonary disease, ECG evidence of ventricular hypertrophy, interventricular conduction delay (QRS duration >100 milliseconds), or Wolff-Parkinson-White syndrome, a chest abnormality or heart malposition, or angiographic evidence of multivessel coronary artery disease were excluded. Coronary reperfusion with either thrombolytic or interventional therapy was performed in all study patients. The CE-CMR images and the ECG recordings taken in the chronic phase between 3 and 6 weeks after the acute phase were analyzed.

Contrast-enhanced cardiovascular magnetic resonance

The location of MI was assessed by CE-CMR using a Philips Intera 1.5-T scanner. All the characteristics of the CE-CMR have been already described in previous papers. The terminology used here for MI location follows the recommendations of the North American Societies of Cardiac Imaging (NASCI) as illustrated in Fig. 2. The inferior and lateral segments of the LV encompass areas perfused by the right coronary artery (RCA) and/or the left circumflex coronary artery (LCX) (inferolateral zone). These infarcts were clustered into 3 groups:

(a) “lateral MI” that involves the lateral wall (segments 5, 6, 11, 12, and 16)
(b) “inferior MI” that involves the inferior wall (segments 4, 10, 15) and the inferior part of the septal wall (segments 3 and 9)
(c) “inferolateral MI” that involves segments of both the inferior and lateral walls

Electrocardiographic criteria

Electrocardiograms were recorded by specially trained nurses following standardized procedures. Two independent cardiologists with expertise in ECG interpretation rated the ECG records blinded to CE-CMR results. The measurements were made by the aid of a magnifying glass. Intra- and interobserver variability, assessed by the intraclass correlation coefficient, were more than 0.95. The following variables were measured in leads V1 and V2 to the nearest 0.5-mm amplitude and 20-millisecond duration:

- R-wave duration and amplitude in V1
- R-wave amplitude in V2
- R/S amplitude ratio in V1
- R/S amplitude ratio in V2
- T-wave polarity and amplitude in V1 and V2.

Table 1
Main electrocardiographic characteristics across MI locations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Inferior MI (n = 15)</th>
<th>Lateral MI (n = 9)</th>
<th>Inferolateral MI (n = 21)</th>
<th>P value *</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-wave duration in V1 (ms)</td>
<td>20 (10 to 30)</td>
<td>40 (10 to 50)</td>
<td>40 (20 to 40)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>R-wave amplitude in V1 (mm)</td>
<td>1.3 (0.5 to 3.0)</td>
<td>3.0 (1.0 to 7.0)</td>
<td>3.0 (0.5 to 8.0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>R/S amplitude ratio in V1</td>
<td>0.20 (0.08 to 0.66)</td>
<td>0.60 (0.09 to 3.50)</td>
<td>0.66 (0.10 to 2.00)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>R-wave duration in V2 (ms)</td>
<td>7.0 (3.0 to 12.0)</td>
<td>7.0 (2.0 to 14.0)</td>
<td>8.0 (2.0 to 20.0)</td>
<td>.439</td>
</tr>
<tr>
<td>R/S amplitude ratio in V2</td>
<td>1.25 (0.26 to 16.00)</td>
<td>0.90 (0.22 to 3.50)</td>
<td>0.87 (0.18 to 15.00)</td>
<td>.695</td>
</tr>
<tr>
<td>T-wave amplitude in V1 (mm)</td>
<td>1.0 (~2.0 to 3.0)</td>
<td>2.0 (1.0 to 3.0)</td>
<td>2.0 (~2.0 to 5.0)</td>
<td>.182</td>
</tr>
</tbody>
</table>

* Kruskal-Wallis nonparametric test.

Results

According to the CE-CMR (Fig. 2), the 45 cases were classified as (a) lateral MI (9); (b) inferior MI (15); and (c) inferolateral MI (21). Twelve of the 15 cases with inferior MI had segment 4 (inferobasal) involvement, and in 5 of these, segment 4 was affected exclusively or predominantly. The median and range values for the ECG variables measured in leads V1 and V2 are shown in Table 1.

In Fig. 3, we present the flow diagram according to the Standards for Reporting of Diagnostic Accuracy (STARD) initiative corresponding to the classical criteria for posterior MI: R/S amplitude ratio in V1 of 1 or greater, and R duration of 400 milliseconds or longer. The specificity of these 2 classical criteria was 100% for lateral or inferolateral MI (no cases with isolated inferior MI presented these criteria), but the sensitivity was low (30.0 and 56.7%, respectively).

We also studied other potential ECG diagnostic criteria of lateral MI location such as R amplitude in V1 and V2, R/S amplitude ratio in V2, and T-wave polarity and amplitude in
Fig. 3. Above: Flow diagram proposed by the STARD initiative for studies on diagnostic accuracy corresponding to the classical Q-wave equivalent increased R-wave criteria in lead V1. Below: Sensitivity, specificity, and likelihood ratios of these criteria for the location of lateral/inferolateral MI.

Sensitivity = 30.0% (95% CI: 15.7-47.9%)  
Specificity = 100% (95% CI: 79.6-100%)  
Likelihood ratio  
for presence: 9.30 (0.58-150.08)  
for absence: 0.72 (0.56-0.94)

Sensitivity = 56.7% (95% CI: 39.2-72.6%)  
Specificity = 100% (95% CI: 79.6-100%)  
Likelihood ratio  
for presence: 17.57 (1.13-273.33)  
for absence: 0.45 (0.29-0.68)

Fig. 4. Above: Box-plots corresponding to the distributions in populations with isolated lateral, isolated inferior, and combined inferolateral MI of three lead V1 variables: (A) R-wave amplitudes in millimeters, (B) R-wave durations in milliseconds, and (C) R/S amplitude ratios. Below: ROC curves corresponding to these three ECG variables to discriminate between lateral/inferolateral MI vs inferior MI.
V1 and V2. However, only R amplitude in V1 and R/S amplitude achieved a good discriminative capacity as assessed by the area under the ROC curve (Fig. 4A and C) and as achieved by the classical criterion on R duration in V1 (Fig. 4B). The lower part of Fig. 4 shows the ROC curves for the ECG criteria that best discriminated between lateral/inferolateral vs inferior MI. The areas under the ROC curves for R amplitude in V1, R duration in V1, and R/S amplitude ratio in V1 were greater than 0.87. The box-plots for these 3 variables according to MI location are presented in the upper part of Fig. 4.

According to these results, we defined 2 new criteria for lateral MI: R wave amplitude in V1 of more than 3 mm and R/S amplitude ratio in V1 of 0.5 or greater. The diagnostic accuracies for these new proposed criteria are presented in Fig. 5. These new ECG diagnostic criteria showed a very high specificity (93.3%) and higher sensitivity than that of the classical criteria (73.3%).

Discussion

The findings of the present study confirm our previous results9,11 that demonstrated that the Q wave equivalent pathologic R waves that appear in leads V1 and V2 as a consequence of an initial acute MI are due to involvement of the lateral and not inferobasal wall of the LV. Furthermore, the new ECG diagnostic criteria in lead V1 presented in this study are useful in discriminating between involvement of the inferior and lateral walls.

Characteristics of an R wave in V1 that best defines lateral MI

In a previous study,11 we demonstrated that a prominent R wave in V1 was not present in isolated inferior MI, even when the basal part of that wall was bent upward and there was clear involvement of the basal portion by CE-CMR. In addition, when the major part of the inferior wall is not positioned on the diaphragm and presents a clear posterior position, as in a lean person, the axial horizontal trans-section of the CMR image shows that the direction of the longitudinal axis of the heart is oriented obliquely rather than posterior-anteriorly. Consequently, in case of infarction, the infarction vector will face V3-V4 but not V1-V2.11-13

In the present study, we demonstrated that the threshold of the R/S amplitude ratio in V1 was less than that previously established for “posterior MI”.1,5 Only one patient with isolated inferior MI had an R/S of 0.5 or greater. The specificity of this criterion for either isolated lateral or combined inferolateral MI therefore remained very high, while attaining with much higher sensitivity than R/S 1 criterion or more (Figs. 3 and 5). The duration of the R wave in V1 was no longer than 30 milliseconds in the majority of cases. In a few cases, however, according to the methodology used, it was a little longer. Because of that, for practical reasons of measurement, we preferred to keep the cut-off point for the R wave width of 40 milliseconds or longer. Consequently, the new criterion R/S amplitude ratio of 0.5 or greater and the amplitude of R in V1 of more than 3 mm were very specific criteria for lateral MI in this study of post-MI patients and achieved higher sensitivity compared to the previous criteria.

Differential diagnosis of a prominent R wave in V1

All of the other situations that may present a tall and wide R wave or an R/S amplitude ratio of 0.5 or greater in V1 should be considered in differential diagnosis when there is no clear evolution after an acute lateral MI. Complete right bundle branch block (RBBB) presents a
wide QRS complex, and Wolf-Parkinson-White syndrome presents a short PR interval and slurred R-wave onset. However, it is especially challenging to rule out right ventricular hypertrophy (RVH) and even acute right ventricular overload (RVO) caused by conditions such as pulmonary embolism. Mild or moderate RVH or RVO of any etiology may produce an ECG pattern with a prominent R wave in V1 that entirely mimics lateral MI, and other noninvasive cardiac tests are required for differential diagnosis. Some malpositions of the heart may also produce a prominent R wave in V1. However, individuals with all these conditions were excluded from our study.

The literature about the normal limits of QRS waveforms confirms that the mean value of R amplitude and the R/S amplitude ratio in V1 in normal adults is clearly lower than 3 mm and 0.5, respectively, although some individuals may present higher value due to the wide range. Furthermore, we have followed our patients prospectively since the admission to the hospital with acute MI until the presented phases in the chronic phase. Therefore in the context of post-MI patients our criteria are very specific for diagnosis and for location of isolated lateral or combined inferolateral MI.

Limitations

Although these results are very consistent for cases of isolated first MI, it would be important to study a series of cases with multi-vessel disease and prior MI to confirm whether these criteria are also useful in these populations. These new criteria will also require confirmation in other series of patients with CE-CMI documentation of the presence and location of MI. Furthermore, these new criteria can be tested in the Selvester QRS scoring system to determine whether they provide improved ECG estimation compared to the classical criteria of CE-MRI measured infarcts in the lateral wall of the left ventricle.

Conclusions

(1) New ECG criteria for lateral MI (R/S ratio in V1 of 0.5 or greater and R amplitude in V1 >3 mm) attain very high specificity and acceptable sensitivity for lateral MI. (2) New criteria based on R waves in V2 or T waves in V1-V2 do not discriminate between inferior and lateral MI. (3) The classical criteria (R/S amplitude ratio ≥1 and R duration ≥40 ms in V1) attain very high specificity but much lower sensitivity than the new criteria.

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