Localization of Anterior Myocardial Infarction: Correlation between Delayed Enhancement, "Scar" Magnetic Resonance Imaging and Electrocardiographic Findings

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Synopsis: ECG localization of myocardial infarction (MI) is widely used despite its limitations. Delayed enhancement (DE) myocardial imaging provides a means for non-invasive identification of irreversibly injured myocardium with high spatial resolution. This study evaluated the spatial localization, size and extent of MI as determined by ECG criteria, compared to DE cardiac MRI in 23 patients with isolated anterior MI. The results confirm that absence of Q-waves does not exclude prior myocardial infarction or scar tissue. In addition, ECG's have high sensitivity for identifying anterior wall MI, but poor specificity for identifying basal, septal, and apical regions of infarction.

Background:

In the late 1940s, Myers et al. established the electrocardiographic (ECG) criteria for localizing myocardial infarction (MI) by comparing ECG findings with autopsy data [1,2]. Since then, despite multiple studies based on autopsy findings, animal studies, and angiographic data, the criteria outlined by Myers et al. have been subjected to only a few modifications [3-6]. In general, while clinicians innately recognize that the accuracy of the spatial localization of MI using ECG is confounded by such factors as age, size, extent and location of the infarct, position and orientation of the heart within the chest, LV hypertrophy or dilatation, and presence of multiple infarcts [7], the ECG continues to be used to localize MI. Recent developments in contrast-enhanced, delayed enhancement (DE) cardiac MRI provide a means for non-invasively identifying irreversibly injured myocardium with very high spatial resolution [8]. Therefore, we hypothesized that MRI could be used to determine the accuracy of ECG based spatial localization of MI.

Purpose:

The purpose of the study was to evaluate the diagnosis, spatial localization, and size and extent of MI as determined by the ECG criteria as compared to infarction information obtained from the DE MRI images in patients with isolated anterior MI.

Methods:

Patient Population: Patients with isolated, anterior wall MI, as determined by the delayed enhancement MRI were included in this retrospective study (n=23, 19-male, 61+/-13 age). Nine of the 23 patients were imaged within 14 days of the infarction as determined by cardiac enzyme levels.

MRI data acquisition: All MRI data were collected at 1.5T (Philips NT-Intera, Rel. 7.x and Rel. 8.x). Fifteen minutes after the administration of Gd-DTPA (0.2 mmol/kg), a stack of short axis slices covering the entire LV were acquired using inversion-recovery prepared segmented gradient echo (T_1-TFE) technique during breath-holding. (Field-of-View: 320-400 mm; matrix: 256x256; slice thickness/gap: 10mm/0 mm; 10-12 slices depending on size of heart; TR/TE/flip=7.1/1.5/15 deg; acquisition duration/RR interval: 180-200 msec; 16-18 heartbeats. The inversion delay time (TI) was iteratively adjusted to null the signal from the normal myocardium (170-250 msec).

ECG data: Standard 12-lead ECGs were obtained within a week of the MRI for patients with acute MI and within 6 weeks for those with chronic MI.

MRI data analysis: The short axis MRI data were analyzed using the AHA standardized 17-segment model [9] to assess the extent of infarct (signal intensity > 2SD above the normal remote myocardium). Each segment was graded as follows: 0: no-infarct; 1: 1-25% infarct; 2: 26-50% infarct; 3: 51-75% infarct; 4: 76-99% infarct; 5: 100% infarcted (transmural). The percent area of infarction (PAI) was calculated as: $(N_{inf}*S_{inf})/(N_{tot}*S_{tot})*100$, where N_{inf}, and N_{tot} are the number of infarcted and total segments respectively, and S_{inf} is the sum of scores of the infarcted segments and S_{tot} is the maximum possible score (i.e., 17*5).

ECG analysis: Two experienced cardiologists reviewed the 12-lead ECGs for: (i) Evidence of Q-waves (duration ≥0.04 s), (ii) ST segment elevation (≥ 0.1 mV), and (iii) T-wave inversion.

Results: *MRI Results:*

Spatial Localization of Infarction: All patients had varying degrees of involvement of the anterior wall; 17/23 (74%) had extension into the apex, 17/23 (74%) with superior and/or inferior septal involvement, and 7/23 (30%) with extension into the anterolateral wall.

Extent of Infarct: The mean percent infarct as described above was: 15 +/- 13, ranging from: 0.4 to 53%.

ECG Data:

Spatial Localization of Infarction: ECG data correctly identified the presence of infarction in 19/23 (83%) cases. ECG criteria correctly identified 12/17 (70%) infarct extensions into the apex, but identified only 10/17 (59%) when septum was involved, reflecting poor spatial localization by ECG.

Q-wave Data: Q-waves were present in V_{1-2} in 4 patients (17%), V_{1-3} or V_{2-3} in 6 patients (26%), and V_{1-4} or V_{2-4} in 5 patients (22%), and extended into leads V_5 or V_6 in 2 patients (8%). Diagnostic Q-waves were completely absent in 4 patients (17%). ECG and MRI results from one such patient is shown in Figures 1 and 2.

Conclusions:

(i) ECG's have a high sensitivity for identifying anterior wall MI.
(ii) The specificity for identifying involvement of basal, septal, and apical regions in anterior MI is poor.
(iii) The absence of Q-waves does not rule out either prior myocardial infarction or presence of scar tissue.

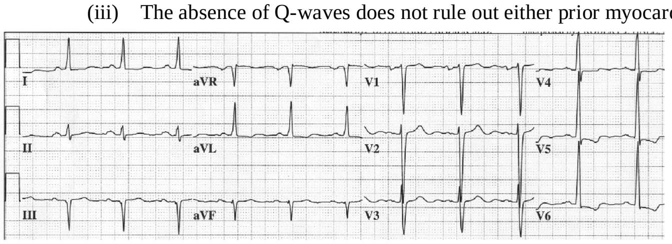

Figure 1: ECG tracing from a patient with an anterior-septal infarction with no Q-waves in the precordial leads.

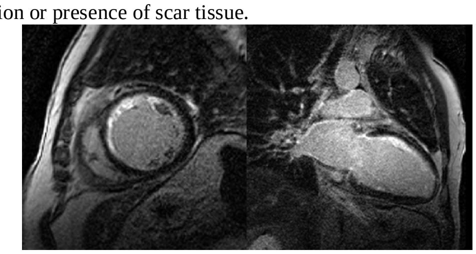

Figure 2: DE images from the same patient reflecting irreversible injury in the subendocardial region of the anterior wall in the short axis (left) and 2-chamber long axis view (right).

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