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The Selvester QRS Score is more accurate than Q waves and fragmented QRS complexes using the Mason-Likar configuration in estimating infarct volume in patients with ischemic cardiomyopathy ☆

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Abstract Infarct volume independently predicts cardiovascular events. Fragmented QRS complexes (fQRS) may complement Q waves for identifying infarction; however, their utility in advanced coronary disease is unknown. We tested whether fQRS could improve the electrocardiographic prediction of infarct volume by positron emission tomography in 138 patients with ischemic cardiomyopathy (ejection fraction, 0.27 ± 0.09). Indices of infarction (pathologic Q waves, fQRS, and Selvester QRS Score) were analyzed by blinded observers. In patients with QRS duration less than 120 milliseconds, number of leads with pathologic Q waves (mean, 1.6 ± 1.7) correlated weakly with infarct volume ($r = 0.30$, $P < .05$). Adding fQRS increased the number of affected leads (3.6 ± 2.5), but the significant correlation with infarct volume was lost ($r = 0.02$, $P = .10$). Selvester Score was the most accurate (mean, 5.9 ± 4.9 points; $r = 0.49$; $P < .001$). Fragmented QRS was not predictive of infarct size in patients with QRS duration of at least 120 milliseconds ($r = 0.02$, $P = .19$). Thus, in ischemic cardiomyopathy, consideration of fQRS complexes does not improve Q wave prediction of infarct volume; but Selvester Score was more accurate.
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Keywords: Electrocardiography; Positron emission tomography; Infarct volume; Ischemic cardiomyopathy

Background

In patients with left ventricular (LV) systolic dysfunction and heart failure, the extent of infarction has been shown to predict the progression of symptoms, survival, and response to therapies (ie, biventricular pacing) and appears to be more useful than ejection fraction (EF) or LV volumes.[1,2] In addition, coronary revascularization offers greater benefit among those with limited infarction.[3,4] Although infarct volume can be accurately quantified by magnetic resonance imaging,[5,6] single photon emission computed tomography (SPECT),[7-9] or positron emission tomography (PET),[1,3,10] an accurate electrocardiographic (ECG) parameter would be desirable in view of its routine acquisition and affordability. The most specific ECG sign of a previous myocardial infarction (MI) is the presence of pathologic Q waves. However, Q waves are relatively insensitive because of poor representation of certain myocardial regions (posterior segments), the increasing incidence of non–Q wave infarctions, and the eventual disappearance of Q waves in approximately one third of patients.[11] Despite these well-acknowledged limitations, Q waves are still useful in assessing infarct location and extent[6]; and a greater "Q wave burden" has been shown to predict larger infarct volume in patients with ischemic cardiomyopathy.[10]

Recent data have shown that in patients with suspected coronary artery disease, the additional consideration of

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fragmented QRS complexes (fQRS) can improve the sensitivity for identifying previous infarction[8] and can also predict greater stress perfusion abnormalities.[9] Furthermore, fQRS are present in a majority of patients with previous Q wave infarction,[12] frequently persist even when Q waves disappear,[12] and may be applicable to patients with wide QRS complexes (≥120 milliseconds).[13] We therefore hypothesized that the consideration of fQRS complexes should improve the identification of MI in patients with more extensive coronary artery disease and ischemic cardiomyopathy and fQRS should complement Q wave burden in the prediction of infarct volume. To gauge the accuracy with which the combined criteria of Q wave or fQRS could predict infarct volume as quantified by PET, these correlations were also compared with the previously validated Selvester QRS scoring system for infarct volume estimation.[14,15]

Methods

Patients for this investigation were drawn from the Prediction of Arrhythmic Events With Positron Emission Tomography study that is an ongoing National Institutes of Health–sponsored observational trial evaluating PET imaging to predict sudden cardiac death (SCD) in patients with ischemic cardiomyopathy.[16] This study is enrolling patients with documented coronary artery disease, New York Heart Association (NYHA) functional class I to III heart failure symptoms, and an EF less than or equal to 0.35 who are eligible for primary prevention of SCD. Patients with recent MI or revascularization were excluded, as were those who had indications for the secondary prevention of SCD (ie, unexplained syncope, sustain ventricular arrhythmias). Consecutive patients (N = 138) with both a 12-lead ECG and PET-quantified infarct volume were included.

ECG indices of infarction

Twelve-lead ECGs were recorded using H12+ Holter recorders (V3.12; Mortara Instruments, Milwaukee, WI). To optimize signal quality, the patient's skin was shaved (if necessary), rubbed with alcohol wipes until thoroughly clean, and briskly dried with gauze to stimulate capillary flow. Disposable pregelled silver chloride electrodes were applied in the Mason-Likar lead configuration, in which limb lead electrodes are placed on the torso rather than the distal extremities. All leads were simultaneously acquired at a high resolution (1000 samples per second), resulting in high-fidelity recordings with a frequency response of 0.05 to 60 Hz. Notably, the Selvester QRS Score and fQRS analysis requires recording of frequencies up to 120 Hz for high-frequency features of the QRS complex, including notching and fractionation, that could be missed with a recording using the Holter standard of 60 Hz.[13] The first ECG of the monitoring period was selected to ensure a resting supine position; and with the ELI LINK program (Mortara Instruments), a single 12-lead ECG was exported into a portable document format with the standard filter setting at 0.05 to 150 Hz for subsequent analysis.

Computer-quantified QRS duration was averaged over 1 minute using all leads, and patients were divided into those with narrow (<120 milliseconds) vs wide (≥120 milliseconds) QRS complexes.[8] Although computer-quantified intervals tend to overestimate manual measurements, automated measurements have less variability and are thus more reproducible.[17] All ECGs (N = 138) were printed on paper at standard speed (25 mm/s) and calibration (10 mm/mV) for evaluation of ECG indices of infarction (fQRS, Q waves, and Selvester Score). Wide-complex ECGs were only evaluated for fQRS complexes because of the poor specificity of Q waves in this setting.[18,19]

Pathologic Q waves and QRS fragmentation

Two investigators, blinded to all clinical data, independently interpreted the ECG for the presence or absence of pathologic Q waves and fQRS complexes (Fig. 1). For ECGs with a narrow QRS (n = 52), *pathologic Q waves* were defined as duration of at least 40 milliseconds and greater than one fourth the voltage of the subsequent R wave.[8] *Fragmented QRS* was defined as follows: (*a*) any RSR morphology, (*b*) notching in the nadir of the S wave, or (*c*) more than one R wave (R'), with the exclusion of incomplete right bundle-branch block.[8] In the presence of an intrinsic wide QRS rhythm (n = 45), fQRS was defined as various RSR' patterns with or without Q waves, with more than 2 R waves (R') or more than 2 notches in the R wave, or more than 2 notches in the S wave.[13] In the presence of ventricular paced rhythms (n = 41), fQRS was defined as the presence of more than 2 R' or more than 2 notches in the nadir of the S wave.[13] Leads V_1 and aVR were excluded from the analysis because of the frequent presence of nonspecific Q waves[20] and to maintain consistency with previously published analyses.[13] In cases of disagreement, final characterization was determined by a third investigator who was also blinded to all clinical information. For the combined analysis of "Q waves or fQRS," a lead was considered to have evidence of infarction if there was either a Q wave or fQRS (for a maximum of 10 leads). In addition to a simple summation of the number of leads with evidence for infarction,[6,10] an analysis was performed requiring 2 contiguous leads within a major coronary territory (anterior—leads V_2, V_3, V_4, and V_5; inferior—leads II, III, and aVF; lateral—leads I, aVL, and V_6.[8,21] Subjects were subsequently divided into the following groups: at least 1 territory with evidence of infarction, at least 1 lead but no territory with evidence of infarction, and no leads with evidence of infarction.

Selvester QRS Score

The predictive accuracy of Q waves and fQRS complexes to estimate myocardial infarct volume was compared with the previously validated Selvester QRS Score[14] by a reviewer blinded to all clinical data. This scoring system consists of 57 ECG criteria used to assign up to 32 points, each of which corresponds to infarction of 3% of the LV. Criteria are based on wave duration (Q or R), wave amplitude (R or S), and amplitude ratios (R/Q or R/S).