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Electrocardiography

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The Accuracy of Electrocardiographic Q Waves for the Detection of Prior Myocardial Infarction as Assessed by a Novel Standard of Reference

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Summary

Background: The electrocardiogram (ECG) is valuable for the identification of prior myocardial infarction (MI) in individuals participating in epidemiologic studies or undergoing screening examinations. Although the Minnesota Code, a set of criteria for the interpretation of ECGs in such situations, is commonly used to identify MI in these settings, its accuracy is incompletely understood.

Hypothesis: We sought to test the accuracy of the Minnesota Code Q and QS criteria for MI against a new standard of reference, the presence of a perfusion defect on a resting myocardial scintigraphic image.

Methods: The resting myocardial scintigrams of all patients studied in our nuclear cardiology laboratory during 7 consecutive months were screened for the presence of perfusion defects. For each patient with such a defect, two individuals examined on the same day, who had no perfusion defect, were selected as controls. Electrocardiograms recorded within 30 days of the scintigraphy were read blindly by two of the authors using the Minnesota Code criteria for Q or QS waves indicative of MI.

Results: For 214 patients selected on the basis of their scintigraphic findings, a satisfactory ECG recorded within a month of the scintigraphy was also available. The overall sensitivity of the Q or QS criteria was 0.58 and the specificity was 0.75. As might be expected when only the most stringent criteria were applied, sensitivity was least and the specificity best.

Conclusions: As in previous studies, in which necropsy material served as the standard of reference, sensitivity of the Q and QS criteria contained in the Minnesota Code is relatively modest and specificity is reasonable but not outstanding.

Key words: electrocardiography, myocardial infarction, myocardial scintigraphy

Introduction

For a test to be of value for epidemiologic studies or screening examinations, its sensitivity, specificity, and predictive accuracy must be understood. In both settings, the electrocardiogram (ECG) is valuable for the identification of patients with prior myocardial infarction (MI). Specifically, an abnormality of the initial deflection of the QRS complex (usually an abnormal Q wave) provides an important indicator. An ECG reader uses the width (duration) and depth (amplitude) of the putatively abnormal initial deflection to separate a Q wave indicative of an MI from one that is a part of the normal sequence of ventricular activation. The wider and deeper the initial deflection, the greater the likelihood that MI has in fact occurred. Despite general reliance on such findings, only a few studies have actually tested the accuracy of various criteria to separate an abnormal Q wave from those of a more benign origin. Such studies have employed necropsy[1] or angiographic[2] observations as standards of reference against which to assess the properties of the ECG criteria.

A widely employed set of criteria for abnormality of Q and QS waves is the Minnesota Code. Developed by Blackburn *et al.* in the 1950s and 1960s,[3] it continues to be a standard, particularly in epidemiologic studies. We sought to assess its accuracy against a new standard of reference, the presence of a perfusion defect on a resting myocardial scintigraphic image.

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Methods

The institutional review board of the Medstar Research Institute approved this investigation.

The resting thallium myocardial scintigrams of all patients, who were studied in our nuclear cardiology laboratory between January 1 and July 31, 1998, were screened. When the official interpretation described a perfusion defect, the patient was selected for analysis and assumed to have had a prior MI. Two additional patients undergoing scintigraphy on the same day, in whom no resting defect was present, were also included; they were considered not to have had a prior MI. Patients with no available standard 12-lead ECG recorded within the 30 days preceding the scintigraphy were excluded, as were those with left bundle-branch block, Wolff-Parkinson-White syndrome, or paced rhythms, and as those known to have cardiomyopathy or to have had a prosthetic valve replacement.

Two observers blinded to the scintigraphic findings independently classified each ECG with regard to Minnesota Code criteria for Q and QS wave abnormality (Table I). Electrocar-

TABLE I The Minnesota Code for Q and QS waves[6]

Most stringent criteria (Minnesota Code 1.1)
- Anterolateral site (leads I, aVL, V-6)
  - QR amplitude ratio ≥ 1/3, plus Q duration ≥ 0.03 s in lead I or V-6
  - Q duration ≥ 0.04 s in lead I or V-6
  - Q duration ≥ 0.04 s, plus R amplitude ≤ 3 mm in aVL
- Posterior (inferior) site (leads II, III, aVF)
  - QR amplitude ratio ≥ 1/3, plus Q duration ≥ 0.03 s in lead II
  - Q duration ≥ 0.04 s in lead II
  - Q duration ≥ 0.05 s in lead III, plus Q-wave amplitude ≥ 1.0 mm in the majority of beats in lead aVF
  - Q duration ≥ 0.05 s in lead aVF
- Anterior site (leads V-1–V-5)
  - Q/R amplitude ratio ≥ 1/3 plus Q duration ≥ 0.03 s in any of leads V-2–V-5
  - Q duration ≥ 0.04 s in any of leads V-1–V-5
  - QS pattern when an initial R-wave is present in an adjacent lead to the right on the chest, in any of leads V-2–V-6
  - QS pattern in all leads V-1–V-4 or V-1–V-5

Intermediate criteria (Minnesota Code 1.2)
- Anterolateral site (leads I, aVL, V-6)
  - QR amplitude ratio ≥ 1/3, plus Q duration ≥ 0.02 and < 0.03 s in lead I or V-6
  - Q duration ≥ 0.03 and < 0.04 s in lead I or V-6
  - QS pattern in lead I (in absence of LBBB)
- Posterior (inferior) site (leads II, III, aVF)
  - QR amplitude ratio ≥ 1/3, plus Q duration ≥ 0.02 and < 0.03 s in lead II
  - Q duration ≥ 0.03 and < 0.04 s in lead II
  - QS pattern in lead II (absent LBBB)
  - Q duration ≥ 0.04 and < 0.05 s in lead III, plus Q-wave amplitude ≥ 1.0 mm in the majority of beats in lead aVF
  - Q duration ≥ 0.04 and < 0.05 s in lead aVF
  - Q amplitude ≥ 5.0 mm in leads III and aVF

Anterior site (leads V-1–V-5)
- Q/R amplitude ratio ≥ 1/3 plus Q duration ≥ 0.02 and < 0.03 s in any of leads V-2–V-5
- Q duration ≥ 0.03 and < 0.04 s in any of leads V-2–V-5
- QS pattern in all leads V-1–V-3 (absent LBBB)
- Initial R amplitude decreasing to ≤ 2 mm in every beat (absent LBBB, large R in V-1, and RBBB)

Least stringent criteria (Minnesota Code 1.3)
- Anterolateral site (leads I, aVL, V-6)
  - QR amplitude ratio ≥ 1/5 and < 1/3, plus Q duration ≥ 0.02 and < 0.03 s in lead I or V-6
  - Q duration ≥ 0.03 and < 0.04 s, plus R amplitude ≥ 3 mm in aVL
- Posterior (inferior) site (leads II, III, aVF)
  - QR amplitude ratio ≥ 1/5 and < 1/3, plus Q duration ≥ 0.02 and < 0.03 s in lead II
  - Q duration ≥ 0.03 and < 0.04 s in lead III, plus Q-wave amplitude ≥ 1.0 mm in the majority of beats in lead aVF
  - Q duration ≥ 0.03 and < 0.04 s in lead aVF
  - QS in each of leads III and aVF (absent LBBB)
- Anterior site (leads V-1–V-5)
  - Q/R amplitude ratio ≥ 1/5 and < 1/3 plus Q duration ≥ 0.02 and < 0.03 s in any of leads V-2–V-5
  - QS pattern in V-1 and V-2 (absent LBBB and tall R waves in V-1)

Abbreviations: LBBB = left bundle-branch block, RBBB = right bundle-branch block.

diograms were assigned the most stringent grade into which they fit (1.1, 1.2, 1.3). Joint review and remeasurement were used to resolve discrepant interpretations.

Dual-isotope, single-photon emission computed tomographic imaging is routinely employed in our laboratory. The resting images are acquired after intravenous injection of thallium. Stress studies employing sestamibi are performed subsequently. The interpretation by the responsible nuclear medicine physician was used for this analysis. This interpreter was blinded to the ECG findings.

Results

For 214 patients (107 men, 107 women, mean age 63 ± 12.3 years) selected on the basis of their scintigraphic findings, satisfactory ECGs recorded within a month of the scintigraphy were also available. Table II depicts the results of the comparison of the presence of a defect on resting thallium imaging and the ECG findings classified in accordance with the Minnesota Code. When one of the most stringent criteria for a significant Q or QS wave is met, the record was classified as 1.1. Records were classified as 1.2 and 1.3 when less stringent criteria were met. The sensitivity of the Q or QS abnormality using any of the criteria from all three levels was 0.58 and the specificity was 0.75. As might be expected when only the most stringent criteria were applied, sensitivity was least and the specificity best. Sensitivity was improved by making the criteria less stringent to include 1.2 and 1.3, but specificity declined (Table III). Indeed, half of Q or QS waves classified as abnormal by these criteria were false positive (Table II).

Discussion

This study compared standard ECG criteria for MI (Minnesota Code) with a novel standard of reference, the presence of a perfusion defect on resting myocardial scintigraphy. The sensitivity and specificity of the ECG criteria in our analysis are consistent with those of Uusitupa *et al.*[1] who made a similar comparison using necropsy material. That study and ours both indicate that when all Q and QS criteria are applied, sensitivity is relatively modest and specificity is reasonable but not outstanding. When only the most stringent (1.1) criteria are applied, sensitivity declines but a false positive diagnosis is rare (Tables II, III). An understanding of these test characteristics is particularly important since these criteria are often employed for ECGs used for screening or epidemiologic purposes.

Our conclusions are limited by our assumption that MI is an all-or-none phenomenon when, in fact, it may be transmural or not, and may be large or small. Similarly, a resting scintigraphic defect may be large or small and may reflect a modest reduction or, indeed, a near absence of counts. In fact, studies have shown that the amount of residual tracer uptake in a perfusion defect relates directly to the amount of remaining myocardial tissue.[4, 5] Therefore, both the size of the MI and the degree to which it is transmural contribute to the prominence of the defect on scintigraphy. Thus, it seems likely that the larger the MI, the more readily both the scintigraphy and the ECG will be able to detect it accurately. Confirmation of these assumptions must await analysis of a larger number of patients. Furthermore, it is well recognized that Q waves often become smaller or disappear entirely with the passage of time after an MI.[6] This evolution may also affect the correlation of ECG and scintigraphic observations, since we are aware of no information addressing the frequency with which resting perfusion defects resolve following MI.

The validity of the use of resting myocardial perfusion defects as an indicator of MI is, of course, pivotal in this analysis. It is important, however, to consider that in some instances intense ischemia may account for such defects.[7, 8] Thus, some of the 29 false negative ECG results may have really been true negatives. Insofar as that is true, the sensitivity of the Minnesota Code Q or QS waves would be underestimated and the predictive value of a negative test improved.

We chose the criteria from the Minnesota Code for this investigation because they are frequently applied when a structured, standardized ECG interpretation is required. These criteria are too cumbersome to be employed in routine clinical practice and do not take advantage of the scalar vector concepts that many cardiologists find valuable. We had, however, a broader motive for undertaking this comparison. We wished to assess preliminarily the practicality of using resting myocardial scintigraphy as a standard of reference for investigations of the accuracy of QRS abnormalities for the identification of prior MI.

Conclusions

The sensitivity of Minnesota Code criteria for the detection of prior MI is modest, just over 0.55, even when the least stringent criteria are employed, and it becomes progressively poor-

TABLE II Frequency of myocardial perfusion defects at rest related to the presence of abnormal Q-waves

Code	Defect (%)	No defect (%)	Total
1.1	21 (77.8)	6 (22.2)	27
1.2	9 (45.0)	11 (55.0)	20
1.3	10 (34.5)	19 (65.5)	29
None	29 (21.0)	109 (79.0)	138
Total	69 (32.2)	145 (67.8)	214

TABLE III Sensitivity, specificity, and predictive accuracy of Minnesota Code for prior myocardial infarction

Code	Sensitivity	Specificity	+ Pred. value	− Pred. value
1.1	0.30	0.96	0.78	0.74
1.1 + 1.2	0.43	0.88	0.64	0.77
1.1 + 1.2 + 1.3	0.58	0.75	0.53	0.79

er as more stringent criteria are employed. Specificity is quite high with the strictest criteria (0.96) but declines to 0.76 when criteria are made less stringent to gain improved sensitivity.

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Images in Cardiology: Interventricular Septal Dissection

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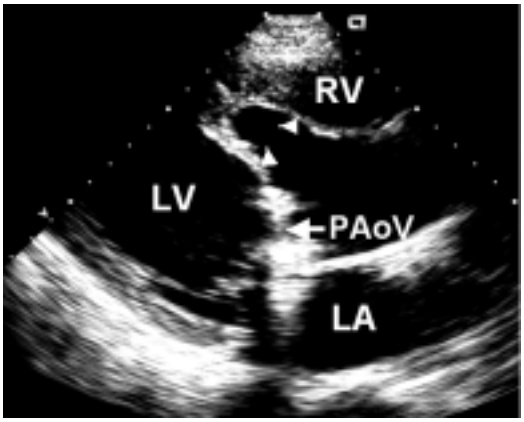

FIG. 1 Parasternal long-axis view during systole showing the dissected interventricular septum (arrowheads) and prosthetic aortic valve (PAoV, arrow). RV = right ventricle, LV = left ventricle, LA = left atrium.

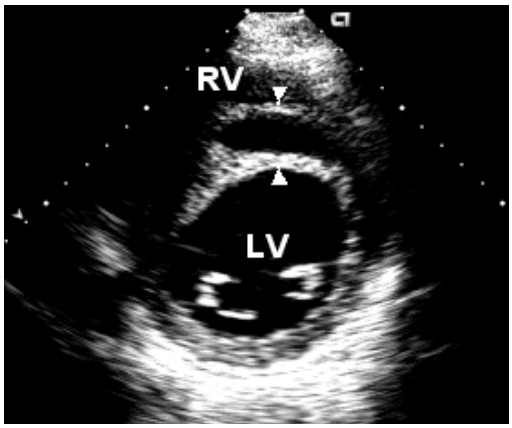

FIG. 2 Parasternal short-axis view during systole showing LV cavity with a dissected interventricular septum (arrowheads).

Dissection of the interventricular septal wall is a very rare condition, usually associated with sinus of Valsalva aneurysm.[1] A 45-year-old man, who had had aortic valve replacement surgery for severe aortic regurgitation two years prior to admission presented with increasing dyspnea (NYHA class II). Cardiac echocardiography showed an interventricular septal dissection from the prosthetic aortic valve to the papillary muscle level of the left ventricle. The patient had Behcet's disease, which only became apparent during the present admission. Homograft aortic valve replacement surgery was performed and an autopericardial patch was applied to the torn septum.

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