Electrocardiography in Women
Taking the Initiative

Peter M. Okin, MD

In the just over 100 years since the first ECG was performed,1 the ECG has become the most extensively used noninvasive diagnostic and prognostic tool in cardiology. Used both at rest and during provocative exercise, the 12-lead ECG has impressive, if imperfect, utility for rhythm analysis, detection of ischemic and hypertrophic heart disease, and outcome prediction in a variety of clinical settings, with a large body of literature that illustrates and supports these applications. The first observation of gender differences in the ECG was published 85 years ago by Bazett,2 demonstrating that women have significantly longer QT intervals than men despite having higher heart rates. However, despite a growing body of literature demonstrating significant gender differences in QRS amplitudes and durations,1,3-6 QT intervals,5,7,8 ST-segment deviation,9,10 and novel, computer-based measurements of T-wave complexity,8,11 few ECG criteria routinely use gender-specific diagnostic criteria, and there has been a relative paucity of data on the prognostic performance of ECG variables in women.

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

From the Division of Cardiology, Department of Medicine, Cornell Medical Center, New York, NY.

Correspondence to Peter M. Okin, MD, Cornell Medical Center, 525 E 68th St, New York, NY 10021. E-mail pokin@med.cornell.edu
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Currently in use, which potentially limits the applicability of this finding. Given the significant correlations of the QRS/T angle with other repolarization variables and the similar predictive value of these variables in the single-ECG models, it would have been informative to examine whether use of traditional measures of repolarization such as T-wave amplitudes and ST-segment deviation would have provided similar levels of prognostic value in the multi-ECG models if QRS/T angle was not included in the analyses. In addition, the greater risk concentration provided by the QRS/T angle may in part reflect the use of 2 levels of abnormality, borderline and high, with the greatest risk found in the widest-angle group. It is possible that similar risk stratification may have been observed if the ST segment in V₅ had been further examined in the abnormal range at levels below −50 µV, particularly given that the partition value used for ST depression in V₅ was not based on its distribution in the study population.²⁻¹³ Third, use of mean amplitude values from the orthonormal expansion and not more standard peak amplitude measurements that are routinely available and familiar to most physicians may limit applicability of the specific thresholds for abnormality in these studies. Finally, given the large number of black women in the population and known ethnic differences in ECG measures,⁵,¹⁸ it is unclear why ethnicity was not included as a covariate in their analyses. As noted by the authors,¹² further evaluation of possible variations in their findings by ethnicity will be important.

The importance of continued examination of the ECG in women and the further development of gender-specific ECG criteria is highlighted by the fact that the use of identical diagnostic criteria in men and women can adversely affect performance of ECG criteria for left ventricular hypertrophy and for the detection of coronary disease during exercise testing.⁶,¹⁰ We and others have demonstrated that women, both with and without hypertrophy, have lower QRS voltages and shorter QRS durations than men, even after adjustment for gender differences in left ventricular mass and body weight.⁶ As a consequence, when non–gender-specific criteria are employed, the ECG exhibits higher specificity and lower sensitivity for the detection of hypertrophy in women than in men. Similarly, women with coronary disease have significantly less exercise-induced ST depression than men.¹⁰ As a result, non–gender-specific ST depression and heart-rate adjusted ST depression criteria have lower sensitivity in women than in men.¹⁰ Use of gender-specific test criteria with matched specificity in both men and women significantly improves sensitivity in women without reducing test sensitivity in men.¹⁰ Gender differences have also been demonstrated in the total cosine of the R-to-T⁶,¹⁸ a measure of the vectorial deviation between the depolarization and repolarization wave front that is similar in concept to the QRS/T angle used by Rautaharju et al,¹²⁻¹⁴ and in other novel measures of T-wave complexity that have been demonstrated to stratify arrhythmic and mortality risk,⁸,¹¹ but these findings are based on data in only a limited number of women. Further study of these variables in larger populations of women will be necessary to adequately assess potential differences between men and women.

Discussion of the possible mechanisms for the gender differences in ECG measures is beyond the scope of this editorial. However, a recent review²⁰ of sex differences in cardiac repolarization provides an extensive discussion of the experimental data and potential gender differences in cellular-level ionic currents and the possible roles played by sex hormones in some of the better-characterized gender differences in cardiac repolarization.

The findings by Rautaharju and colleagues¹²,¹³ have important implications and provide direction for future investigation. Despite the widespread misconception that the ECG is of limited utility in women, these studies clearly demonstrate the value of the ECG for risk stratification in women, in particular the strong prognostic value of ECG measures of abnormal repolarization when using threshold criteria derived in women. Taken together with the wealth of information documenting the predictive value of the ECG in men, these findings strongly support the routine clinical application of computer-based ECG measurements for risk stratification in women. The known gender differences in QRS duration and amplitudes raise the question of whether sex-specific criteria for MI or bundle-branch blocks may be indicated to further enhance the predictive value of these ECG variables in women. Additional comparisons of ECG measurements in men and women will be necessary to more clearly delineate true mechanistic differences in ECG variables between men and women from differences that may be attributable to gender differences in left ventricular mass, body size, and composition, with application of these findings to improve accuracy of the ECG in both women and men.

In light of the low cost and widespread availability of the ECG and the increasing economic pressures on the practice of medicine, it is imperative that we continue to improve the diagnostic and prognostic performance of the ECG in women. Now that we have seized the initiative with respect to ECG research in women, we should not let it go to waste.

References


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