Our data suggest that increased QT dispersion is a marker of electrical instability and predicts PMVT/VF after AVNA, particularly in association with depressed left ventricular systolic function. Patients showing marked QT dispersion require careful monitoring after AVNA.


Reproducibility of the ST-Segment Depression/Heart Rate Analysis of the Exercise Electrocardiographic Test in Asymptomatic Middle-Aged Population

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It has been shown that noninvasive diagnosis of coronary artery disease can be improved by analyzing the ST-segment depression against heart rate (ST/HR) during the exercise electrocardiographic (ECG) test. Recently, the ST/HR hysteresis, a variable that integrates the diagnostic information of both the exercise and recovery phases of the test, was found to be the most accurate diagnostic variable based on the ST/HR analysis. However, further refinement of the ST/HR analysis would require adequate knowledge of inherent (e.g., method-induced) nondiagnostic variability in the above variables. This information on reproducibility has been scarce so far and limited to patients with coronary artery disease. Knowing especially the magnitude of intra-individual variability in healthy asymptomatic populations would be crucial if one wishes to determine whether a longitudinal change in a diagnostic variable is large enough to indicate that a change with real diagnostic value has happened. Therefore, the objective of this study was to determine the reproducibility of the ST/HR hysteresis, ST/HR index, and end-exercise ST depression in an asymptomatic middle-aged population, an age-cohort that is most often referred to exercise ECG tests.

Maximal exercise ECG tests were performed twice within a period of 6 to 8 months in 61 middle-aged (51 to 54 years) healthy volunteers (28 men and 33 women). The subjects gave informed consent before the study. Each subject was sedentary (vigorous

FIGURE 3. Measured QT dispersion decreases significantly with an increased pacing rate in group 1 patients who developed polymorphic ventricular tachycardia after AV nodal ablation. There is no significant change in those patients who did not have this complication.
exercise no more than twice a week), nondieting, nonsmoking, and not excessively obese (body mass index <33). One month before the first maximal test, the subjects accustomed themselves to the testing procedure by performing a submaximal test. According to careful medical screening done before the subjects showed any clinical signs of evolving heart or other disease. The clinical data of the study group are given in Table I.

All subjects were tested on a bicycle ergometer in the exercise physiology laboratory of the UKK Institute (Tampere, Finland). Each test was conducted by 1 of the 3 experienced technicians of the institute. The initial workload was 10 W for women and 20 W for men, and was increased by 10 and 20 W every minute for women and men, respectively. The ECG recordings and HR measurements were done with a Marquette CASE 12 recorder (Marquette Inc., Milwaukee, Wisconsin). The respiratory quotient (RQ) was used as an index of maximality of the maximal exercise testing. Between the repeated tests the subjects were asked to keep their living habits unchanged, and during the study period none of the subjects showed any clinical signs of evolving heart or other disease. The clinical data of the study group are given in Table I.

All continuous data were expressed as mean ± SD. The reproducibility of the exercise ECG variables between the repeated measurements was determined as recommended by Bland and Altman. Definition of reproducibility was ±1.96 times the SD of the differences between the pairs of measurement (SDba) using the same method. This range corresponds to 95% limits of agreement within which intra-individual changes should be considered nonsignificant due to inherent variability of the method. As another measure of reproducibility, the agreement of interpretation between the repeated measurements was defined as the percentage of the subjects in which the interpretation of both measurements was the same. It was determined separately for each of the 3 exercise ECG variables using specific fixed partition values that provided equal specificity of 80% for each method in detecting coronary artery disease in our previous study. These positive test criteria were ST/HR hysteresis ≥0.010 mV, ST/HR index ≥1.60 μV/beats/min, and end-exercise ST depression ≥0.10 mV. The agreements of interpretations between the repeated measurements with different variables were compared by McNemar modification of the chi-squared test. Because of the 3 comparisons, the p value <0.017 (Bonferroni correction) was required for rejection of null hypothesis.

Maximal exercise tests were successful at both testing sessions (maximum HR achieved [172 ± 11 vs 172 ± 11 beats/min], RQ [1.15 ± 0.06 vs 1.14 ± 0.07]). The reproducibilities were ±0.040 mV, ±1.24 μV/beats/min, and ±0.11 mV for the ST/HR hysteresis, ST/HR index and end-exercise ST depression, respectively. The Bland–Altman plots are immediately before starting the exercise with the patient sitting on the bicycle, at the end of each minute of exercise, at the end-exercise, and every 12 seconds during the first 3 consecutive minutes of postexercise recovery. A continuous piecewise linear function was obtained by connecting the consecutive ST/HR data pairs of the exercise phase with lines. Similarly, a continuous piecewise linear function for the postexercise recovery phase was constructed by connecting the consecutive ST/HR data pairs of the first 3 minutes of recovery phase starting from the ST/HR data pair at the end-exercise. Then, the difference between the above curves was integrated over the HR from the minimum HR of recovery to the maximum HR. Finally the ST/HR hysteresis was obtained by dividing the integrated net difference by the HR difference of the integration interval in order to normalize the result with respect to the postexercise HR decrement.

The ST/HR index was calculated as the gradient between the ST/HR pairs at the start-exercise and at the end-exercise as suggested by Detrano and co-workers. All continuous data were expressed as mean ± SD. The reproducibility of the exercise ECG variables between the repeated measurements was determined as recommended by Bland and Altman. Definition of reproducibility was ±1.96 times the SD of the differences between the pairs of measurement (SDba) using the same method. This range corresponds to 95% limits of agreement within which intra-individual changes should be considered nonsignificant due to inherent variability of the method. As another measure of reproducibility, the agreement of interpretation between the repeated measurements was defined as the percentage of the subjects in which the interpretation of both measurements was the same. It was determined separately for each of the 3 exercise ECG variables using specific fixed partition values that provided equal specificity of 80% for each method in detecting coronary artery disease in our previous study. These positive test criteria were ST/HR hysteresis ≥0.010 mV, ST/HR index ≥1.60 μV/beats/min, and end-exercise ST depression ≥0.10 mV. The agreements of interpretations between the repeated measurements with different variables were compared by McNemar modification of the chi-squared test. Because of the 3 comparisons, the p value <0.017 (Bonferroni correction) was required for rejection of null hypothesis.

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The agreement of interpretation between the repeated measurements of the ST/HR hysteresis was significantly better than that of the ST/HR index (p = 0.0045) or the end-exercise ST depression (p = 0.0010), whereas no significant difference was observed between the ST/HR index and the end-exercise ST depression (p = 0.32).

Given the large intra-individual variability of ECG recordings at rest, the reproducibility of the exercise ECG variables is apparently bound to be relatively poor, a fact that was actually confirmed in this study in asymptomatic middle-aged individuals. The magnitude of change in the variable, which has to be observed to make the clinician confident that a real diagnostic change has occurred, was surprisingly large as indicated by the Bland-Altman plots in Figure 1. However, the possibility that some of the subjects may have developed a significant change in their coronary status is not definitely ruled out, but given that coronary atherosclerosis occurs over a period of decades, one would not expect to find any substantial coronary changes in 6 to 8 months. It is worth noting that the agreement of interpretation with the ST/HR hysteresis appeared to be significantly better than those with the ST/HR index or end-exercise ST depression.

The findings of this study on reproducibility of the exercise ECG variables in 61 asymptomatic middle-aged subjects give further support to the clinical utility of the ST/HR hysteresis. The results also indicated that the observed change in the exercise ECG variable between repeated measurements must be large to make the clinician confident that a real diagnostic change has occurred.

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