Modes of heart rate compensations during exercise ECG test

Egzersiz EKG stres test sırasında kalp hızı kompansasyon şekilleri

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ABSTRACT

Heart rate (HR) compensation of electrocardiographic (ECG) parameters is not an unique concept. However, in the detection of coronary artery disease (CAD) ST-segment plotted as a function HR has been studied extensively during the last 20 years. In clinical practice quantitative methods are evolved for the exercise phase of the exercise test and post-exercise recovery phase has not been studied as extensively. Quantitative parameters, as ST/HR hysteresis, which represents the average difference in ST depressions between the exercise and recovery phases at an identical HR up to three minutes of recovery, has been shown to improve the detection of CAD. Furthermore, the ST/HR parameters have been demonstrated to be very competent in a prediction of mortality. *(Anadolu Kardiyol Derg 2005; 5: 312-4)*

Key words: Exercise electrocardiography, ST-segment, heart rate, coronary artery disease

ÖZET

Elektrokardiyografik (EKG) parametrelerin kalp hızı (KH) kompansasyonu pek de nadir bir kavram değildir. Ancak, son 20 yıl içinde, ST segment KH bağıntısı yaygın olarak araştırılmaktadır.

Klinik pratikte egzersiz testin egzersiz fazının değerlendirmesinde nicel yöntemler uygulanmaktadırlar ancak egzersiz sonrası iyileşme fazı enine boyuna araştırılmamıştır. ST/KH histeresis,aynı KH egzersiz ve iyileşme fazlarının (iyileşme fazının 3. dakikasına kadar) ST depresyonların ortalama farkı gibi nicel parametreler koroner arter hastalığının belirlemesini kolaylaştırdığı gösterilmiştir. Buna ek olarak, ST/KH parametreler mortalitenin öngörülmesinde da yararlı oldukları bildirilmiştir. *(Anadolu Kardiyol Derg 2005; 5: 312-4)*

Anahtar kelimeler: Egzersiz elektrokardiyografi, ST-segment, kalp hızı, koroner arter hastalığı

Introduction

Heart rate (HR) is one of the most important parameters to monitor during exercise electrocardiogram (ECG) test. Changes in the HR have an effect on other ECG parameters. However, in the determination of ECG parameters the HR compensation has been used only for the QT interval (e.g. Bazett's QT correction by RR interval). The inclusion of HR in ST-segment analysis has been proposed over 30 years ago. In the end 1960's Bruce and McDonough (1) have demonstrated the competence of ST-segment changes as a function of HR in the detection of coronary artery disease (CAD). The 1980's were very intensive era for the investigations of different ST/HR methods during exercise phase. Recently investigators have suggested that the diagnostic accuracy of the exercise test in the CAD detection can be improved by considering also ST-segment and HR changes during recovery (2). Furthermore, several studies have demonstrated a good competence of the attenuated HR response to exercise, chronotropic index (3, 4), and reduced decrease in HR after exercise (5, 6) in a prediction of mortality.

ST-Segment Heart Rate Diagram

After the first publication of HR compensation of ST-segment, it took over decade until the beginning of the 1980 Elamin and colleagues (7) reported results with a new exercise test parameter, the ST/HR slope, assumed to detect the presence and severity of CAD. The ST/HR slope was measured as the maximal rate of progression of ST-segment depression relative to increases in HR. The unit for the ST/HR slope is μV/beats per minute (bpm) (Fig. 1). Apparently in consequence of the complexity of calculating the ST/HR slope, a simple modification of the slope, designated the ST/HR index, was introduced by Detrano and associates (8). This index proportions the ST segment alteration during exercise to the change in HR from rest to peak effort (Fig. 1). The unit for the ST/HR index is also μV/bpm. Since the introduction of the ST/HR slope and index several researchers have demonstrated their superior diagnostic capability over the conventional ST depression in the detection of CAD (9-12).

The observation of the ST-segment by HR compensation has been concentrated on the exercise phase of the exercise test. Bruce and McDonough's visual evaluation method for the ST-segment deviation in the exercise and recovery phases was quantitatively proved in 1989 by Okin and associates (13). This Cornell group introduced a dichotomous diagnostic variable, the HR recovery loop, which provided significantly better diagnostic accuracy in the detection of CAD than did the standard ST depression criterion. The HR recovery loop records whether the ST depression at 1 minute of recovery is less or greater than that at

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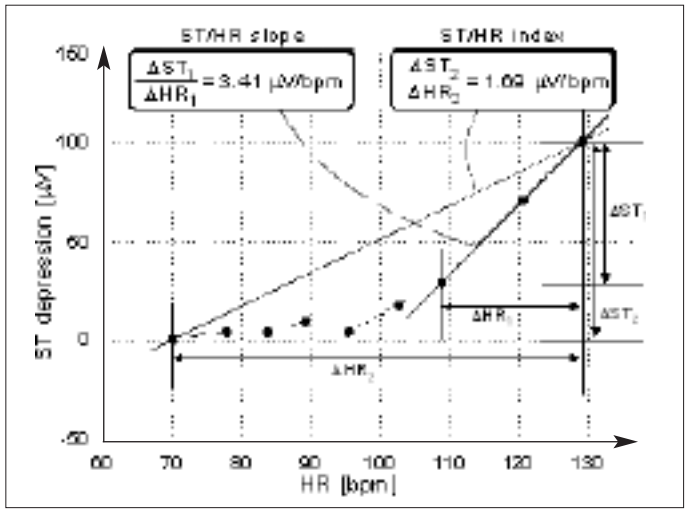

Figure 1. Calculation of the ST/HR slope and ST/HR index. ST-segment depression is plotted against exercise HR (negative values indicate ST elevations). The ST/HR slope is defined by linear regression as the final three (or more) data points. The ST/HR index is obtained by dividing the total change in ST-segment depression by the total change in HR.

HR = heart rate; bpm = beats per minute.

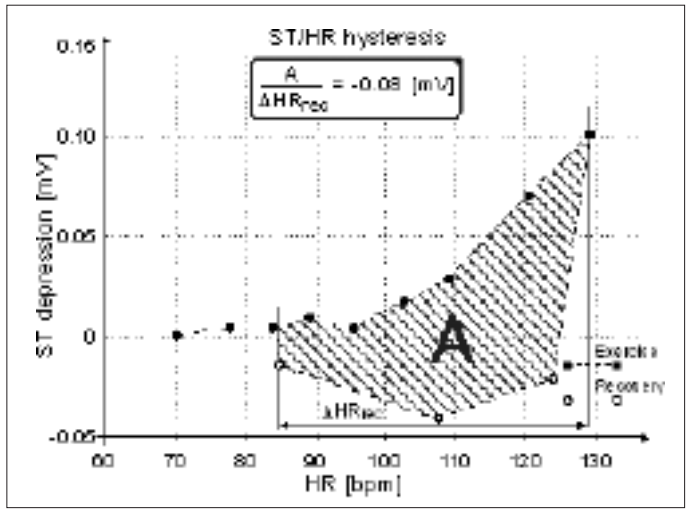

Figure 2. Determination of ST/HR hysteresis from the ST/HR diagram of a single ECG lead. ST and HR data pairs are plotted immediately prior to start of exercise, at the end of each minute of exercise, at peak exercise, and at the end of the first three minutes of recovery.

A = area between the recovery and exercise ST depression values;
ECG – electrocardiogram, HR = heart rate; bpm = beats per minute.

matched HR during exercise. However, the HR recovery loop considers only the first minute of the recovery period, although the subsequent period may convey relevant information. In addition, the magnitude of the ST depression difference between the exercise and recovery phases relative to HR may have independent diagnostic potential. For this reason, the continuous ST/HR variables, which utilize the diagnostic information provided by the ECG during the post-exercise recovery phase, have recently become a target for development and study.

Our research group has developed the continuous variable, ST/HR hysteresis (2, 14), which presents the average difference in ST depressions between the exercise and recovery phases at an identical HR up to three minutes of recovery. The ST/HR hysteresis has been shown to significantly improve the detection of CAD (2), to be less sensitive to the selection of lead (14) and the measurement point (15), to have better reproducibility (16) and to improve diagnostic accuracy among women (17) compared to the traditional methods. Likewise, other groups (18-24) using a similar methodology combining ST-segment analysis during the exercise and recovery phases of the test have achieved improved diagnostic accuracy over the traditional ECG variables. Also prognostic value of the recovery ST/HR parameters has been demonstrated to be very competent (23, 25).

Discussion

To achieve accurate analysis of the ECG parameter in the detection of ischemic heart disease, the observation of parameter should be made as function of the HR. The observation should not be restricted to the exercise phase, but should be continued several minutes in the recovery phase. In addition to the visual examination, the quantitative values of ST/HR diagram give additional information for supporting physician's decision-making. The ST/HR hysteresis and other similar methods combining the exercise and recovery ST-segment values at the identical HR have been shown to be superior compared to the traditional parameters.

Despite the exercise ECG has been studied over 50 years in the detection of CAD and in prognosis, it is not at all completely explored. Recent studies have shown that improved detection of CAD and more reliable prognosis can be achieved using sophisticated method combining ECG parameters with HR and focusing to the recovery phase of exercise test.

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