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ORIGINAL ARTICLE

How accurate can electrocardiogram predict left ventricular diastolic dysfunction?

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KEYWORDS

Hump sign;
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P wave dispersion

Abstract *Background:* Heart failure continues to be a major challenge to healthcare; several resting and exercise electrocardiographic parameters have been investigated to predict the left ventricular diastolic dysfunction (LVDD).

Objectives: We aimed to study different parameters in resting and exercise stress test to evaluate whether they can predict left ventricular diastolic dysfunction (LVDD).

Methods: One hundred and forty patients, classified into 2 groups according to LVDD, were assessed by measurement of normal and corrected QT interval, T wave peak to T wave End and P wave dispersion in resting ECG. Exercise stress test looking for hump sign (upward deflection of the ST-segment) was done. The relationships between these ECG parameters and LVDD were investigated.

Results: We found significant occurrence of hump sign in patients with LVDD, and there was a significant difference between both groups regarding QTc and P wave dispersion. P wave dispersion was significantly higher in patients with LVDD. Sensitivity and specificity of the ST hump sign in prediction of LVDD were 86% and 78% respectively. We also concluded that P wave dispersion at cutoff value about 0.045 ms had the highest sensitivity (sensitivity 98%, specificity 64%) while QTc at cutoff value 0.395 ms had the highest specificity (sensitivity 81%, specificity 79%).

Conclusion: P wave dispersion and hump sign were the most sensitive ECG signs for the prediction of LVDD.

1. Introduction

Approximately half of patients with heart failure (HF) have a preserved ejection fraction (HFpEF). Morbidity and mortality are similar to HF with reduced EF (HFrEF), yet therapies with unequivocal benefit in HFrEF have been shown not to be effective in HFpEF. Recent studies have shown that the pathophysiology of HFpEF, initially believed to be principally due to diastolic dysfunction, is more complex. Appreciation of this complexity has shed new lights onto how HFpEF patients might respond to traditional HF treatments, while also suggesting new applications for novel therapies and strategies.[1]

While inherited long QT syndrome (LQTS) has historically been considered a purely electrical disease, echocardiographic

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studies over the past two decades have demonstrated a crude but replicable relationship between a prolonged QT interval and abnormal mechanical function.[2] Observational data paired with animal studies suggest that electrical transmural dispersion of repolarization, manifest on the surface electrocardiogram (ECG), can be associated with mechanical dispersion of left ventricular relaxation observed using comprehensive echocardiography.[3]

P wave dispersion (PD) is related to the nonhomogenous and interrupted conduction of sinus impulses intra and inter-atrially. Currently, PD is described as a noninvasive indicator of atrial fibrillation risk, which can be calculated easily on a 12-lead surface ECG.[4]

Sauer et al., revealed in a sample of 84 consecutive outpatients referred for exercise echocardiography, a significant inverse linear association between the TpTe interval and tissue Doppler septal E' velocity. This association persisted after adjustment for several important potential confounders, including age, QTc interval and left ventricular wall thickness.[5]

The standard interpretation of the exercise stress test includes an evaluation of symptoms, exercise capacity, hemodynamics, and changes in ECG. Although ST depression and elevation are the most important ECG findings, a number of other parameters have been shown to be of diagnostic and prognostic value. Among these is a discrete upward deflection of the ST segment termed the ST hump sign (STHS). Previous studies have shown that this sign represents atrial repolarization and leads to false positive exercise tests.[6]

STHS has been associated with hypertension, which is characterized by myocardial hypertrophy, diastolic and systolic myocardial dysfunction, fibrosis, and limitation in subendocardial flow reserve.[7]

2. Aim of the study

In this study, we aimed to study different parameters in resting and exercise stress test and evaluate whether they can predict left ventricular diastolic dysfunction (LVDD) diagnosed by Tissue Doppler Echocardiography.

3. Patients and methods

This Prospective study was carried out in the department of cardiology, El-Minia University hospital during the period from November 2012 to November 2013.

Four hundred eighty patients were referred for stress ECG for risk stratification of coronary artery disease. Out of these, 140 consecutive patients (96 males and 44 females) were included in this study by the following inclusion criteria:

- Patients not known to have any history of ischemic heart disease.
- Patients with negative exercise stress test.
- Patients with positive exercise stress test and normal coronary angiography (False positive stress test).
- Normal resting ECG changes (No LBBB, RBBB or Wolf Parkinson White syndrome).
- Normal left ventricular systolic dysfunction.
- These patients not receiving anti-arrhythmic drugs or any drugs that can affect QT interval as:

1. Class 1 or class 3 anti-arrhythmic as amiodarone, sotalol, procainamide, quinidine, ibutilide.
2. Psychotropic agent as tricyclic antidepressants, tetracyclic agents, haloperidol, phenothiazines.
3. Antibiotics as erythromycin pentamidine.
4. Others as astemizole, terfenadine, cisapride.

Exclusion criteria included a true positive stress test.

The cohort of patients included 135 patients with true negative stress test and 5 patients (1 male and 4 females) with false positive stress test. The diagnosis of positive stress test was based upon the upward sloping ST segment depression more than one and half small square.

All included patients underwent an echocardiographic estimation of the diastolic function of the left ventricle, using conventional and Tissue Doppler Imaging (TDI) techniques. We considered the patient had diastolic dysfunction when $E/E' = 15$ or more by tissue Doppler Echocardiography [6].

Parameters that were analyzed included the following.

3.1. Resting ECG

1. *QT interval:* This is measured from the beginning of QRS complex to the end of T wave. QT interval should be measured in the longest interval present in ECG. We also used rate corrected QT or QTc which can be obtained by dividing the actual QT by the square root of RR interval.[8]
2. *P wave dispersion:* This is calculated by subtracting the minimum P wave duration from the maximum P wave duration. P wave duration is calculated from the beginning of P wave deflection crossed isoelectrical line to the last P wave deflection crossed isoelectrical line.[9]
3. *TpTe interval:* it is measured from the T wave peak to the T wave end in resting ECG and it represents transmural dispersion of repolarization.[10]

3.2. Treadmill exercise testing

All patients performed exercise testing on an exercise stress test (GE Medical System, Milwaukee, WI). The ECG was recorded continuously during exercise and for up to 10-min during the recovery period.

The results for each set of leads were recorded and analyzed separately. Blood pressure was measured every 2 min, during exercise and during the recovery period, with a standard mercury sphygmomanometer. Exercise was terminated if there was severe angina, fatigue, dyspnea or severe arrhythmias. In the absence of symptoms, the test was terminated at the occurrence of 2 mm ST-segment depression or 1 mm ST-segment elevation, an increase in systolic blood pressure more than 230 mmHg or a decrease 20 mmHg or more or inability to exercise furthermore.[7,11]

ECG measurements were performed with a magnifying lens by 2 experienced investigators. ST-segment hump sign was defined as a discrete upward deflection of the ST-segment that any of the leads of the ECGs received during exercise. It was mostly observed in leads II, III, aVF, V1 to V6.

Atrial repolarization is represented by a wave (Ta) with direction opposite to that of P wave that may extend up to