How reliable is the electrocardiogram in detecting left ventricular hypertrophy in hypertension?

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Summary: This paper assesses the sensitivity and specificity of the electrocardiogram in detecting left ventricular hypertrophy in 75 hypertensive patients. Each patient underwent a 12 lead electrocardiogram and echocardiogram. Left ventricular mass index, using echocardiogram, was calculated according to the Penn convention and left ventricular hypertrophy was assessed by standard electrocardiographic criteria.

The electrocardiogram was found to be very specific but insensitive in the detection of left ventricular hypertrophy as compared with the echocardiogram. Other non-voltage dependent markers appeared to have similar reliability.

We conclude that the electrocardiogram may be unreliable in the detection of left ventricular hypertrophy in hypertensive patients. Accurate assessment of left ventricular hypertrophy, in these patients should be by echocardiography.

Introduction

Left ventricular hypertrophy imparts a substantial risk of morbidity and mortality.1 Echocardiography has permitted the reliable, non-invasive estimation of left ventricular mass.2 However, most physicians have relied on the electrocardiogram to detect the presence of left ventricular hypertrophy in hypertension. Several electrocardiographic criteria have been suggested, including the Romhilt-Estes point score,3 Sokolow-Lyons voltage criteria,4 and the presence of ST-T wave changes (‘strain’).5 We conducted a study to assess the sensitivity and specificity of the electrocardiogram in detecting left ventricular hypertrophy in patients with essential hypertension.

Patients and methods

Eighty-six patients with treated essential hypertension between the ages of 30–65 were enrolled in a prospective study. The mean duration of treatment was 2 years (95% CI 1–3 years). Patients with previously known myocardial infarction or angina were excluded. All patients came off their drug therapy for a period of 2 weeks. Each patient underwent a 12 lead electrocardiogram and an echocardiogram on the same occasion. In addition, measurements of resting blood pressure and anthropometric measurements were made.

Echocardiography was performed, using a Hewlett Packard Sonos 500 series echocardiograph, by the same trained technician. The echocardiogram was performed in the left lateral position and all recordings were obtained during quiet respiration. The echocardiogram was coded and independently analysed by two experienced investigators. Left ventricular mass (LVMII) was calculated using the Penn convention2 and corrected for body surface area. A left ventricular mass index of >115 g/m² (mean ± 2 s.d. of 35 normal subjects in our laboratory) was considered to be indicative of left ventricular hypertrophy.

The electrocardiogram was recorded on a Hewlett Packard pagewriter and independently interpreted by both investigators who were also unaware of the echocardiographic findings. Left ventricular hypertrophy was assessed by two commonly used methods. The Romhilt-Estes point score system3 (using a score based on amplitude and duration of the QRS complex in limb and precordial leads, a score of 4 or greater indicating left ventricular hypertrophy) and the Sokolow-Lyons score4 (using a sum of amplitude SV₁ and RV₅ or RV₆ > 35 mm and RV₅ or RV₆ > 26 mm indicating left ventricular hypertrophy). Other non-voltage markers of left ventricular, i.e. ST-T wave changes, left atrial abnormalities (terminal negativity of P in lead V₃) and left axis deviation (axis < −30°) were also studied. In addition the combination of voltage criteria of left ventricular
hypertrophy (SV$_1$ and RV$_s$ or RV$_6$ > 35 mm) with ST-T wave inversion ("LVH with strain") was also studied.

A standard Bayes analysis was used to calculate sensitivity, specificity and diagnostic accuracy for electrocardiographic criteria of left ventricular hypertrophy present on the echocardiogram. Comparison of quantitative variables was performed using standard least-square linear regression analysis.

**Results**

Of the 86 patients studied, 75 had diagnostic quality echocardiograms for analysis. Hence, analysis was restricted for these 75 patients. The mean (s.d.) systolic blood pressure was 184 (14) mmHg and mean (s.d.) diastolic blood pressure was 104 (10) mmHg. Of these, 49 (39 males, mean age 55 years, range 35–65) had echocardiographic left ventricular hypertrophy (mean 165 g/m$^2$, range 130–390) and 26 (20 males, mean age 54 years, range 30–65) did not show left ventricular hypertrophy (mean LVM1 = 104 g/m$^2$, range 89–114). There was no difference in blood pressure between the two groups.

Calculated sensitivity, specificity and accuracy for the electrocardiographic criteria assessed are given in Table I.

The Romhilt-Estes point score system was highly specific but had a low sensitivity and the correlation with echocardiographic left ventricular mass index was poor ($r = 0.28$). The Sokolow-Lyons criteria was also highly specific but was less sensitive and correlation with echocardiographic left ventricular mass index was poor ($r = 0.17$). Both scores had similar sensitivity and specificity in men and women.

The combination of voltage left ventricular hypertrophy with ST-T wave inversion was very specific but sensitivity was poor. We also evaluated other non-voltage markers of left ventricular hypertrophy. Isolated ST-T wave changes had a poor sensitivity and moderate specificity. Left atrial abnormalities and isolated left axis deviation had similar sensitivity and specificity. Further analysis of the data showed similar diagnostic accuracy in overweight (body weight $> 110\%$ ideal body weight) when compared with non-obese subjects.

**Discussion**

Echocardiographic criteria for left ventricular hypertrophy have been shown to have excellent sensitivity, specificity and accuracy when compared with postmortem left ventricular mass, and

<table>
<thead>
<tr>
<th><strong>Criteria</strong></th>
<th><strong>Sensitivity</strong></th>
<th><strong>Specificity</strong></th>
<th><strong>Accuracy</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Romhilt-Estes score</td>
<td>20.4% (10/49)</td>
<td>96% (25/26)</td>
<td>46%</td>
</tr>
<tr>
<td>Sokolow-Lyons score</td>
<td>16% (8/49)</td>
<td>100% (26/26)</td>
<td>45%</td>
</tr>
<tr>
<td>LVH with strain</td>
<td>15% (7/49)</td>
<td>100% (26/26)</td>
<td>44%</td>
</tr>
<tr>
<td>ST-T wave changes*</td>
<td>16.3% (8/49)</td>
<td>70% (18/26)</td>
<td>34%</td>
</tr>
<tr>
<td>Left atrial abnormality**</td>
<td>48.2% (24/49)</td>
<td>55% (14/26)</td>
<td>50%</td>
</tr>
<tr>
<td>Left axis deviation***</td>
<td>35% (17/49)</td>
<td>15% (4/26)</td>
<td>28%</td>
</tr>
</tbody>
</table>

* = isolated ST-T wave depression; ** = isolated terminal -ve P in V$_1$; *** = left axis $< -30\%$.

its reliability has also been confirmed angiographically.

The homogenous population we studied permitted the assessment of Romhilt-Estes point score and Sokolow-Lyons criteria in a clearly defined clinical setting. In our population, both the electrocardiographic criteria appeared to have a very low sensitivity due to a high incidence of false negatives but both methods appeared to be very specific (specificity $> 90\%$). Therefore, in a population with prevalence of left ventricular hypertrophy the high false-negative rate renders both criteria of limited value. Both scores were not affected by increasing body weight and had similar sensitivity and specificity in men and women.

Non-voltage markers of left ventricular hypertrophy, including ST-T strain, left atrial abnormality, left-axis deviation, gave diagnostic accuracy similar to the Romhilt-Estes point score and the Sokolow-Lyons score. However, these markers, although more sensitive than the standard electrocardiographic criteria, were consistently less specific ($< 70\%$) except for the combination of voltage left ventricular hypertrophy and ST-T wave inversion which was very specific (100%). Thus, the clinician, when assessing a hypertensive patient, could use any of these criteria as a marker of hypertensive left ventricular hypertrophy. The results of our study differ from the suggestions of early reports where good correlation has been shown between electrocardiographic criteria and echocardiographic post-mortem left ventricular hypertrophy. However, these studies were either population based or involved a heterogeneous group of patients and did not address the specific question of the reliability of the electrocardiogram in hypertensive subjects. Our study
suggests that, in hypertensive subjects, the reliability of electrocardiographic criteria is very poor and that it is less than that in the general population. Recent reports have suggested that echocardiographic left ventricular hypertrophy predicts complications of hypertension in men and women. Due to the low sensitivity and poor accuracy of electrocardiographic diagnosis of left ventricular hypertrophy, we conclude that if accurate assessment of left ventricular hypertrophy is required in hypertensive patients, then this should be done by echocardiography. Such a policy could lead to a large increase in the workloads of echocardiographic departments throughout the country. However, in view of recent reports regarding the prognostic implications of echocardiographic left ventricular hypertrophy in hypertension and the beneficial effects of anti-hypertensive therapy in reducing echocardiographic left ventricular hypertrophy, such a policy could be justified.

References