Sensitivity of Cornell, Sokolow-Lyon, and Romhilt-Estes Electrocardiographic Criteria for Left Ventricular Hypertrophy in Nepalese Population

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Abstract
Introduction: Hypertension with hypertensive heart disease very common cardiovascular problem in Nepalese population and major cause of morbidity and mortality. Left ventricular hypertrophy (LVH) as a marker hypertension can be detected by different ECG criteria as well as echocardiography. Here we study the sensitivity of different electrocardiography (ECG) criteria in detecting left ventricular hypertrophy in patients having LVH on Echocardiography.

Methods: The study was conducted at the Echocardiography department and Out Patient Departhent of Manmohan Cardithoracic Vascular & Transplantnt Center, Institute of Medicine from May 2015 to August 2015. Ninty nine patients of hypertension having LVH on echocardiography were taken. Left ventricular hypertrophy on ECG was assessed by the help of Cornell, Sokolow-Lyon and Romhilt – Estes Point Score.

Results: Mean age of the study population (99 patients) was 56.65± 13.24 and majority of the patients were in age group 50-70. Male to female ratio was 2:1. Mean body mass index of the patients was 25.51±3.5; mean systolic blood pressure was 150.23 ±21.84.Only 13% of patients had normal body weight by Body Mass Index. Among 99 patients, positive Cornell criteria in ECG were noted in 32 patients (32.32%), positive Sokolow criteria in ECG were noted in 43 patients (43.43%) and positive Romhilt–Estes ECG criteria were noted in 31 patients (31.31%).Combining these three criteria LVH was detected in 62 patients (62.62%).

Conclusion: Sokolow–lyon ECG criteria is most sensitivity in detection of left ventricular hypertrophy among Cornell, Suklow –lyon, Romhilt–Estes score. Sensitivity for detecting LVH is significantly increased if combined all these three criteria.

Key words: Hypertension, Left ventricular hypertrophy (LVH), Electrocardiography (ECG), Echocardiography

Introduction
Hypertension, a clinically important medical condition, is typically characterized by a blood pressure more than 140 / 90 mm of Hg. As of recent years, the prevalence of hypertension has been increasing steadily and the total number of expected cases will be tripled within the next decade as per a study done in the Nepalese community published in the Indian heart journal in 2012. The Framingham heart study, in addition to various other studies have shown that left ventricular hypertrophy, detectable via electrocardiography and echocardiography has emerged as an independent risk factor, for cardiovascular morbidity and mortality.

Left ventricular hypertrophy (LVH) is associated with an increased risk of cardiovascular events. Electrocardiography (ECG) and Echocardiography (Echo) are generally used to diagnose LVH. Although Echocardiography is preferred because of its higher sensitivity, ECG is widely used in large-scale research studies and in clinical practice to detect LVH due to its convenience and cost-effectiveness (although it generally has low sensitivity). Additionally, ECG-LVH and Echo-LVH predict mortality independently and provide different prognostic information. Several ECG criteria are available to assess LVH. Among them, Sokolow–Lyon voltage (Sok V) and Cornell voltage criteria are commonly used as voltage criteria.

Many studies have been done with different ECG criteria for LVH and sensitivities of these criteria are different in different studies and population. The aim of this study was to compare the sensitivity of the Romhilt Este, Cornell criteria and Sokolow-Lyon criteria in detecting left ventricular hypertrophy in the Nepalese Population.
Methods

Study population:
In a cross-sectional design, data was obtained from consecutive patients visiting the at the Echocardiography and Outpatient Department of Mannobhan Cardiothoracic Vascular and Transplant Center from May 2015 to August 2015. A total of ninety nine patients of hypertension having left ventricular hypertrophy on echocardiography were selected to undergo an electrocardiogram (ECG). Exclusion criteria were cases with incomplete clinical or hemodynamic data and patients with evidences of myocardial infarction, valvular heart disease (i.e., grade II or more valvular regurgitation or any valvular stenosis), left ventricular Systolic dysfunction, pericardial disease, chronic obstructive pulmonary disease, and rhythm abnormalities including bundle branch blocks, atrial fibrillation or flutter based on a clinical history and examination.

Electrocardiographic measurement
A standard 12-lead ECG was recorded at 25 mm/sec paper speed and 1 mV/cm and was interpreted by a single reader to the patient’s ECG data. Measurement of QRS duration, R-wave amplitudes in leads aVL, V 5, and V 6 and S-wave amplitudes in leads V 1 and V 3 and calculated four ECG criteria: Romhilt Estes, Cornell voltage (Cor V), the Soklow.LVH was conventionally defined as:
Sokolow and Lyon Voltage Criteria:
1. R wave in V5 or V6 > 26mm And / or
2. Sum of S waves in lead V1+ R wave in V5 or V6 > 35mm
Cornell Voltage criteria:
- S in V3 +R in aVL >= 20 mm in Females, 28 mm in Males
Romhilt – Estes Point Score
1. Increased QRS Amplitude (Any of the following)
   - R or S in limb leads > 20mm ........3 points
   - S in V1 or V2, > 30mm ..........3 points
   - R in V5 or V6 > 30mm............3 points
2. Any ST Shift (Opposite to QRS direction) ........3 points
3. Left Axis Deviation >= 30............2 points
4. QRS interval > .09 Sec ..............1 point
5. Intrinsicoid deflection in V5 / V6 > 0.04
   - Sec........1 point
   (Time measured from the beginning of the QRS Complex to the apex of the R Wave)
6. P-terminal force in V1 > .04 Sec. ..3 points
   (A-P wave of left atrial enlargement)
   LVH > 5.0 points

Echocardiographic measurement:
Echocardiography was performed by a single person to prevent intra-observer bias. Images were obtained in left parasternal long axis and short axis views with patients in the left lateral position using VIVID7 echocardiography machine. Only tests with proper interface visualization that showed simultaneous images of septum, left ventricular internal diameter and posterior wall were considered adequate for determination of the left ventricular mass. Left ventricular diameter was assessed using a leading edge to leading edge measurement of the maximal diameter starting from the posterior aortic root to the posterior left ventricular wall at end systole. Left ventricular measurements were taken according to the recommendation of the American Society of Echocardiography (ASE), with the M-mode guided by 2-D mode. Left ventricular systolic and diastolic diameters, interventricular septal and left ventricular posterior wall thickness were measured at end diastole. All the values were recorded in millimeters (mm) and left ventricular hypertrophy (LVH) was defined as Left ventricular septal thickness > 9 mm (females) and > 10 mm (males) respectively.

Statistical Analysis:
The data was entered and analyzed using IBM SPSS® 20. The variables studied were age, gender, diabetes, hypertension, clinical findings (height, weight, body mass index), left ventricular mass, left ventricular mass index, and Left Atrial Size (based on LA diameter). Mean ± S.D. were calculated for age, BMI, left ventricular Mass and left ventricular mass index. Gender and risk factors were expressed as frequency distribution tables. Sensitivities of three different ECG criterias for identifying LVH were calculated.

Results:
Out of the 99 patients studied, mean age of the study population (n=99) was 56.65 ± 13.24 and majority of the patients were in the age group 50-70 years. Male to female ratio was 2:1. Mean body mass index of the patients was 25.51 ± 3.5; the mean systolic blood pressure was 150.23 ±21.84.Only 13% of patients had normal body weight according to body mass index (Table 1). Among 99 patients, positive Cornell criteria in ECG were noted in 32 patients (32.3%), positive Sokolow criteria in ECG were noted in 43 patients (43.4%) and positive Romhilt –East ECG criteria were noted in 31 patients (31.3%) (Table 2 & Figure 1).Combining these three criteria Left ventricular hypertrophy was detected in 62 patients (62.6%).
Table 1: Base line characteristics of the patients

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54.97 ± 10.7</td>
<td>59.85 ± 16.76</td>
<td>56.65 ± 13.24</td>
</tr>
<tr>
<td>Sex</td>
<td>65</td>
<td>34</td>
<td>99</td>
</tr>
<tr>
<td>Body Mass Index (BMI)</td>
<td>25.61 ± 3.6</td>
<td>25.33 ± 3.39</td>
<td>25.51 ± 3.5</td>
</tr>
<tr>
<td>Systolic Blood Pressure (SBP)</td>
<td>151.86 ± 22.95</td>
<td>147.11 ± 20.67</td>
<td>150.23 ± 21.84</td>
</tr>
</tbody>
</table>

Figure 1. Sensitivity of LVH by ECG Criteria.

Table 2. Sensitivity of Romhilt, Sokolow, Lyon, Cornell & Combined LVH Criteria of ECG with Mean left ventricular mass index.

<table>
<thead>
<tr>
<th>LVH Identifier</th>
<th>Status</th>
<th>Mean LV Mass Index (gm/m2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVH (Romhilt Score)</td>
<td>Absent (n=68)</td>
<td>99.74 ± 34.92</td>
</tr>
<tr>
<td></td>
<td>Present (n=31)</td>
<td>94.11 ± 27.47</td>
</tr>
<tr>
<td>LVH (Sokolow / Lyon Voltage Criteria)</td>
<td>Absent (n=56)</td>
<td>94.97 ± 30.94</td>
</tr>
<tr>
<td></td>
<td>Present (n=43)</td>
<td>101.95 ± 34.90</td>
</tr>
<tr>
<td>LVH (Cornell Criteria)</td>
<td>Absent (n=67)</td>
<td>97.43 ± 35.54</td>
</tr>
<tr>
<td></td>
<td>Present (n=32)</td>
<td>99.19 ± 26.38</td>
</tr>
<tr>
<td>LVH (Combined Score)</td>
<td>Absent (n=37)</td>
<td>98.27 ± 35.64</td>
</tr>
<tr>
<td></td>
<td>Present (n=62)</td>
<td>97.87 ± 31.17</td>
</tr>
</tbody>
</table>

Discussion

In recent decades, several studies have been dedicated to the electrocardiographic diagnosis of left ventricular hypertrophy based on criteria related to the deviation of the QRS electrical axis, to voltage and duration of ventricular complex (R and S waves of precordial electrocardiogram), to the time of intrinsicoid deflection in the precordial leads, and also to the polarity and configuration of ST-segment and T wave in several leads.

Different criteria are used alone or in association, comprising according to some authors, scoring systems to increase the accuracy of the method for diagnosing LVH. Echocardiography has shown great accuracy not only in detecting left ventricular dimensions but also in quantifying the thickness of the walls. Since, the introduction of echocardiography as a diagnostic method, several studies of correlation with the conventional electrocardiogram has been published. Rather few Nepalese studies have investigated the performance of ECG criteria for LVH and they have mostly been conducted to improve ECG criteria for assessing LVH. Pewsner et al. They reviewed 21 articles in this systematic review and analyzed six electrocardiographic indices commonly used in diagnosis of left ventricular hypertrophy. In this review, sensitivity of Cornell voltage index ranged from 2% to 41%.
Sokolow-Lyon and Cornell voltage criteria for left ventricular hypertrophy were assessed in patients enrolled in the second phase of MONICA Project\textsuperscript{13}. The sensitivity of Cornell voltage criterion was 22.5\% for males and 28\% for females.

Oberman et al\textsuperscript{14} had a study done among postmenopausal women for evaluation of left ventricular hypertrophy, by using Cornell criterion. They found the sensitivity of Cornell criterion 46\% in women after the adjustment for age and body mass index.

Olungade et al\textsuperscript{15} in a study Assessment of voltage criteria for left ventricular hypertrophy in adult hypertensives in south-western Nigeria showed sensitivity of Cornell criteria was 51.72\%.

In our study the sensitivity of Cornell criteria for detection of LVH was 32.32 \% which is comparable to other studies except lower to Nigerian study may be due to more male population in our study for which Cornell criteria is less sensitive as shown by other studies.

The Romhilt- Estes Point Scoring System was first devised from an analysis of the electrocardiographic changes noted in left ventricular hypertrophy, was originally reported to be 60\% sensitive in diagnosing left ventricular hypertrophy.\textsuperscript{16}

O. prakash et al\textsuperscript{17} in a study left ventricular hypertrophy in hypertension; ECG and Echocardiographic correlation showed that sensitivity of Romhilt score was 14\%. Our study showed that the sensitivity of Romhilt- Estes Score had sensitivity of 31.31\% which is in between these two studies, differences in sensitivity may be due variables like age, sex, exact duration of hypertension, treatment duration, control of blood pressure.

Ogunlade et al\textsuperscript{15} showed that sensitivity of Sokolow Lyon voltage criteria was 58.62\%. Martin et al\textsuperscript{18} in a study of Sensitivity and Specificity of the Electrocardiogram in Predicting the Presence of Increased Left Ventricular Mass Index on the Echocardiogram in Afro-Caribbean Hypertensive Patients showed sensitivity of Sokolow criteria was 31\%.

O prakash et al\textsuperscript{17} in a study left ventricular hypertrophy in hypertension; ECG and Echocardiographic correlation showed that sensitivity of sokolow was 34\%.

KCM et al\textsuperscript{19} in a study diagnostic efficacy of electrocardiography in determining left ventricular hypertrophy in patients with essential hypertension showed sensitivity of Sokolow-Lyon Voltage Criteria was 83\%. Our study showed the sensitivity of Sokolow Lyon voltage criteria has sensitivity of 43.43\% which is comparable to most of the studies.

In detection of LVH based on electrocardiographic findings, this study showed an overall sensitivity of 66\% if Sokolow, Cornell and Romhilt- Estes Point scoring criteria are used in combination. Saba et al\textsuperscript{20} in a study involving diagnostic accuracy of electrocardiography in the diagnosis of left ventricular hypertrophy sensitivity, using combined Sokolow Lyon and Cornell product indices puts the sensitivity of detection at 54.5\%.

**Conclusion**

Electrocardiography can be diagnostic tool in detection of left ventricular hypertrophy if all these three criteria: Romhilt, Cornell, Sokolow Lyon criteria are applied simultaneously where there is no facility of echocardiography. Sokolow-Lyon ECG criteria is most sensitivity in detection of left ventricular hypertrophy among Cornell, Sokolow-Lyon,Romhilt-Estes score.

**Conflict of interest: None declared**

**References:**

20. Saba et al. Diagnostic Accuracy of Electrocardiography in Diagnosis of Left Ventricular Hypertrophy. JIMIC 2014 Vol 9, No. 3, 63-66