

Comparison of Various Criteria Used to Determine Left Ventricular Hypertrophy by Electrocardiography; Validation With Echocardiography

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SUMMARY

A total of 30, consecutive, hypertensive patients, 14 males and 16 females were evaluated for the presence of left ventricular hypertrophy (LVH) by four different electrocardiographic (ECG) criteria i.e. 1) Sokolow and Lyon's precordial voltage criteria of R in V5 or V6 + S in V1 ≥ 35 mm. 2) R in AVL ≥ 11 mm. 3) Romhill-Estes point score ≥ 4 points. 4) Casale's criteria. These were then compared with the echocardiographic findings of LVH which was used as the reference standard. Results showed that Casale's criteria had the maximum sensitivity (50%) vs 25% each for both Sokolow and Lyon's and R in AVL > 11 mm and only 19% for Romhill-Estes point score. The specificity of Casale's criteria was 93% while all the other criteria had a specificity of 100%. In conclusion, Casale's criteria for ECG determination of LVH was almost twice as sensitive as the other criteria tested without losing significantly in specificity.

INTRODUCTION

Hypertensive heart disease is an important and common cause of morbidity and mortality¹. As the systemic arterial pressure goes up, the cardiac workload is increased². To overcome this afterload, certain changes take place in the heart, predominantly in the left ventricle. Initially, it may involve augmented venous return, i.e. preload³, thus increasing ventricular ejection through the Frank-Starling mechanism. Enhanced ventricular contractility may also be achieved through a state of increased adrenergic input to the myocardium⁴. These findings may not only be the adaptive responses of the heart but may actually be part of an overall pathophysiological process in hypertension⁵. In any event, these changes cause increased myocardial tension and subsequent LVH⁶.

Electrocardiography is the most widely available investigation for determining the presence of LVH. Various criteria have been devised over the years to determine this⁷⁻⁹. These criteria differ in their sensitivity and specificity¹⁰⁻¹³. We did a study to compare the sensitivity and specificity of some of

these criteria using echocardiography as the reference standard to confirm the presence of LVH¹⁴.

PATIENTS AND METHODS

The study consisted of 32 consecutive, hypertensive patients who attended the medical outpatient department of Shaikh Zayed Hospital, Lahore, during a period of one month. Patients with history of hypertension (defined according to the Joint National Committee Criteria)¹⁵ were included regardless of their age, sex, weight, height and whether blood pressure was controlled or not at the time of presentation. Patients with evidence of valvular heart disease or ischaemic heart disease were excluded.

Echocardiographic examination of each patient was done by an experienced cardiologist who knew nothing about the severity or duration of hypertension or the patient's medication. Echocardiography was done using a Sonolayer SSH-40A Toshiba machine with a 3.5 MHz transducer in partial left lateral position and all standard views were taken. Left ventricular M-mode echocar-

diagrams were taken just below the tips of the mitral valve leaflets showing clear continuous echoes from both the septum and the posterior wall. Thickness of septum and posterior wall were measured at end-diastole (R wave on ECG)¹⁶. Left ventricular mass was calculated by the formula¹⁷;

- LV mass = $1.04 [(LVID + PWT + IVS)^3 - (LVID)^3] - 13.6g$
- LVID left ventricular internal diameter in diastole
- PWT posterior wall thickness
- IVS interventricular septal thickness

In males, LVH was present when LV mass was greater than 132 g/m² and in females, LVH was present when LV mass was greater than 109 g/m².¹⁸

Standard 12-lead electrocardiograms were done by trained technicians. These were read by another cardiologist who did not know about the echocardiographic findings of the patients. The following different parameters were used for assessing LVH by ECG;

1. Sokolow and Lyon's precordial voltage criteria⁸.
Amplitude of R in V5 or V6 + S in AVF ≥ 35 mm
2. Amplitude of R in AVL ≥ 11 mm.
3. Romhilt-Estes point scoring system⁹.
Patient having 4 or more points.
4. Casale's criteria¹³.

i) At all ages;	Males	Females
R in AVL + S in V3	≥ 35 mm	≥ 25 mm
ii Age < 40 years		
R in AVL + S in V3	≥ 22 mm	≥ 12 mm
T in V1	≥ 0.0 mm	≥ 0.0 mm
iii Age > 40 years		
R in AVL + S in V3	≥ 22 mm	≥ 12 mm
T in V1	≥ 2.0 mm	≥ 2.0 mm

Statistical methods

Statistical definitions were as follows:

$$\text{Sensitivity (\%)} = 100 \times \frac{\text{Patients with disease with positive test}}{\text{All patients with disease tested}}$$

$$\text{Specificity (\%)} = 100 \times \frac{\text{Patients without disease with negative test}}{\text{All patients without disease tested}}$$

$$\text{Correct diagnosis (\%)} = 100 \times \frac{\text{Patients without disease with negative test}}{\text{All subjects tested}}$$

$$\text{Positive predictive accuracy (\%)} = 100 \times \frac{\text{Patients with disease with positive test}}{\text{All subjects tested with positive test}}$$

$$\text{Negative predictive accuracy (\%)} = 100 \times \frac{\text{Patients without disease with negative test}}{\text{All subjects tested with negative test}}$$

RESULTS

A total of 32 consecutive hypertensive patients were evaluated. Two of these were excluded because of inadequate echocardiograms. Of the rest, 14 were males and 16 were females. Ages of the patients ranged from 14 years to 75 years, average being 46.6 years. Duration of hypertension ranged from recently diagnosed to 20 years. Eight patients had blood pressure controlled with medication at the time of presentation while 22 were uncontrolled. A summary of the results is given in Table 1.

It can be seen from Table 1 that a total of 10 out of the 16 females had LVH on echocardiography whereas 6 out of the 14 males in the trial had LVH by echocardiography. Thus, 16 patients out of the total trial population of 30 patients had LVH on echocardiography.

Sokolow and Lyon's precordial voltage criteria correctly identified only 4 of the 16 patients with LVH. Thus, it had a sensitivity of only 25%. However, there was no false positive and the specificity was, therefore, 100%. The positive predictive accuracy was also 100% and the negative predictive accuracy was 54% (Table 2).

The criteria of R in AVL > 11mm also identified 4 true positives and no false positives. Thus, its sensitivity, specificity, positive predictive accuracy and negative predictive accuracy were exactly similar to the Sokolow and Lyon's criteria (Table 2).

The Romhilt-Estes point score only identified 3 of the 16 patients with LVH correctly giving it a sensitivity of only 19%. However, its specificity too was 100% as there was no false positive. The positive predictive accuracy was 100% and negative predictive accuracy was 52%.

According to Casale's criteria, there were 9 cases of LVH based on the ECG. Eight of these were confirmed to have LVH on echocardiography but one patient turned out not to have LVH on

echocardiography. Therefore, this criteria had a sensitivity of 50%, specificity of 93%, positive predictive accuracy of 89% and negative predictive accuracy of 62%.

DISCUSSION

Hypertension is a widely prevalent disease. It causes damage to the various organs in the body. One of the manifestations of this damage is LVH¹⁹. It is difficult to diagnose LVH just on the basis of the clinical examination. Echocardiography has been proven to be a highly sensitive and specific test for determining the presence of LVH¹¹. However, it is a relatively expensive test and is not widely available in Pakistan.

On the other hand, ECG is a relatively inexpensive and widely available test. However, the various criteria used to determine LVH by ECG have proved in different series to be rather insensitive¹⁰⁻¹². Devereux et al. in his series of 148 patients, who were confirmed to have LVH on echocardiography, found that Sokolow and Lyon's criteria had a sensitivity of only 22% but a specificity of 93%¹². In the same series, Romhilt-Estes point score of 4 or more had a sensitivity of 48% and a specificity of 85% while, if the cutoff point was increased to a score of 5 or more, the sensitivity fell to 34% but the specificity increased to 98%.

In our series, the sensitivity and specificity of Sokolow and Lyon's criteria is almost similar to that found by Devereux et al. However, the sensitivity of Romhill-Estes score in our series was considerably lower while the specificity remained high.

Casale et al. devised new criteria in 1985¹³. Using these new criteria, they found that sensitivity for LVH increased to 53% with specificity remaining at an acceptable 89%. In addition, these criteria achieved a high overall accuracy of 73% as well as the the highest predictive accuracy of 80% and negative predictive accuracy of 70%. In comparison, in the same study, Sokolow and Lyon's precordial voltage criteria had a sensitivity of only 20% and a specificity of 93%. The Romhilt-Estes point score, in this study, had a sensitivity of 31% and specificity of only 83%. R in AVL \geq 11mm had a very low sensitivity of 10% but was very specific (99%).

In our study, Casale's criteria had a sensitivity of 50% and specificity of 93% thus paralleling the findings of the original study. We find this criteria to be almost twice as sensitive as the other criteria tested without losing significantly in specificity.

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Table 1:

No.	Sex	LV Mass in G/M ²	LVH by Sokolow	LVH by R in AVL	LVH by Estes	LVH by Casale's
1.	F	166	-	-	-	Yes
2.	M	243	-	-	-	Yes
3.	F	115	-	-	-	-
4.	M	103	-	-	-	-
5.	M	131	-	-	-	-
6.	M	109	-	-	-	Yes
7.	F	128	-	-	-	-
8.	F	115	-	-	-	-
9.	F	180	-	Yes	-	Yes
10.	F	119	Yes	Yes	Yes	Yes
11.	M	134	Yes	Yes	Yes	Yes
12.	M	123	-	-	-	-
13.	M	226	-	-	-	-
14.	M	80	-	-	-	-
15.	F	136	Yes	Yes	-	-
16.	F	172	-	-	-	-
17.	M	110	-	-	-	-
18.	F	203	-	-	-	Yes
19.	M	120	-	-	-	-
20.	F	90	-	-	-	-
21.	M	76	-	-	-	-
22.	F	65	-	-	-	-
23.	F	71	-	-	-	-
24.	F	90	-	-	-	-
25.	F	112	Yes	-	Yes	Yes
26.	M	144	-	-	-	-
27.	F	76	-	-	-	-
28.	M	147	-	-	-	Yes
29.	F	103	-	-	-	-
30.	M	117	-	-	-	-

Table 2:

	Sokolow and Lyon's (%)	R in AVL > 11mm (%)	Estes score (%)	Casale's criteria (%)
Sensitivity	25	25	19	50
Specificity	100	100	100	93
Correct diagnosis	46	46	46	43
Positive predictive accuracy	100	100	100	89
Negative predictive accuracy	54	54	52	62

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