

ELECTROCARDIOGRAPHIC DIAGNOSIS OF LEFT VENTRICULAR HYPERTROPHY: COMPARISON WITH ECHOCARDIOGRAPHY

Waqas Hameed, Muhammad Shamaun Razi*, Muhammad Alamgir Khan, Muhammad Mazhar Hussain, Sohail Aziz**, Shahid Habib[?] Muhammad Aslam,

Dept. of Physiology, Army Medical College, Rawalpindi, *Shifa College of Medicine, Islamabad, **Dept. of Cardiology, Armed Forces Institute of Cardiology / National Institute of Heart Diseases, Rawalpindi [?]College of Medicine, King Saud University, Riyadh, Saudi Arabia

Background: The present study was conducted to determine the sensitivity and specificity of electrocardiographic criteria for the assessment of left ventricular hypertrophy by comparing it with the gold standard of echocardiography. **Methods:** Fifty clinically diagnosed patients of LVH were included in this collaborative study of Dept. of Physiology, Army Medical College, Rawalpindi and Department of Cardiology, Armed Forces Institute of Cardiology, Rawalpindi. ECG of the patients were recorded and Romhilt-Estes point score calculated. This was followed by echocardiography and left ventricular mass and left ventricular mass index was calculated. **Results:** It was found that Romhilt-Estes point score system of ECG had a sensitivity of 35% and specificity 90%. **Conclusion:** It is concluded that the sensitivity of ECG is low in detecting LVH, however, sensitivity can be increased by combining Sokolow Lyons voltage criteria and Cornell voltage criteria with Romhilt-Estes point score. ECG is however still recommended as a routine investigation because of its cost effectiveness and easy availability.

Key words: Left ventricular hypertrophy, ECH, echocardiography, Romhilt-Estes, point score system

INTRODUCTION

There is an increased risk of cardiac morbidity and mortality associated with left ventricular hypertrophy (LVH),¹⁻⁴ so its detection is of major importance, especially for individuals with hypertension or other cardiovascular risk factors. LVH is no longer considered an adaptive process that compensates the pressure imposed on the heart and has been identified as an independent and significant risk factor for sudden death, acute myocardial infarction, and congestive heart failure.^{5,6} According to Devereux et al,⁷ the increase in left ventricular mass represents a common final pathway towards the adverse effects on the cardiovascular system and higher vulnerability to complications.³

Various criteria exist for the electrocardiographic detection of left ventricular hypertrophy (LVH). Electrocardiographic evidence of left ventricular hypertrophy is one of the most widely used markers of cardiovascular morbidity and mortality.⁸ It has become a clinical priority to precociously detect left ventricular hypertrophy by effective, low-cost screening, applicable to the population in general.^{9,10} In spite of their high specificity, the ECG indices are still less sensitive. Although echocardiography has become the gold standard for LVH detection in clinical practice, ECG remains widely used due to its simplicity and accessibility. However ECG criteria for LVH detection exhibit only limited accuracy (generally due to poor sensitivity).¹¹⁻¹⁴ Furthermore, their unrestricted applicability to nonwhite individuals remains to be demonstrated. Historically,

these criteria have been almost exclusively elaborated on and calibrated in white (or mixed) populations, and several interethnic differences in ECG characteristics have been demonstrated.¹⁵⁻¹⁸

The present study was designed to study one of the ECG criteria for detection of LVH by comparing it with the gold standard of echocardiography.

MATERIAL AND METHODS

The present study was conducted from June 2002 to March 2003 in Armed Forces Institute of Cardiology / National Institute of Heart Diseases (AFIC/NIHD). Fifty patients of either sex between the ages of 13 – 65 years who were provisionally diagnosed by the cardiologist on the basis of clinical signs and symptoms, for LVH were included in the study.

Obese, smokers, and patients with physical abnormalities of chest wall such as kyphosis or scoliosis were excluded from the study. Known cases of ischemic heart diseases, obstructive lung disease and patients manifesting ECG findings of bundle branch block, atrial fibrillation or flutter and Wolff Parkinson-White syndrome were not included. Patients on digitalis therapy or other drugs, which can alter ECG, were also excluded.

General physical examination of the patients was done and detailed history was taken. Body surface area and body mass index using the Mosteller formula^{19,20} were calculated. A standard 12 lead ECG was recorded with subjects lying comfortably in supine position by Cardiofax electrocardiograph. The machine was calibrated before recording ECG with

paper speed at 25mm/sec and amplitude of stylus deflection at 1mV/cm. Romhilt Estes point score was calculated (Table 1). The scores ranged between zero (minimum score) and 13 (maximum score).

In the present study a score of = 5 points was considered as LVH. Using 2-D echocardiogram as a guideline M-mode recording was obtained with the help of Toshiba Power Vision 6000 machine. Left ventricular posterior wall thickness (LVPWT), left ventricular internal diameter (LVID) and interventricular septal thickness (IVS), in both systole and diastole, were measured. Left ventricular mass (LVM) was calculated by using Devereux's anatomically validated formula.²¹

$$LVM = 1.04[(LVIDd + IVS + LVPWT)^3 - (LVIDd)^3] - 13.6$$

Left ventricular mass index (LVMI) was calculated and cut off value for LVH in males and females was taken as 108 gm/m² and 100gm/m² respectively.²²

Data was analyzed by SPSS version 11. Sensitivity (%) was calculated by dividing true positives by the sum of true positives and false negatives, then multiplying the quotient by 100. Sensitivity is the quality of a test to diagnose true cases. Specificity (%) was calculated by dividing true negatives by the sum of true negatives and false positives, then multiplying the quotient by 100. Specificity is the quality of a screening test to identify healthy cases. Cases diagnosed as LVH on both ECG and echocardiography were labeled as True Positive. Those patients who were not diagnosed as LVH on both ECG and echo were True Negative. Those patients whose ECG did not reveal any findings of LVH but were diagnosed as LVH by echocardiography were False Negative. Positive predictive value, negative predictive value and diagnostic efficacy of the Romhilt – Estes point score system were also calculated.

RESULTS

The age of the patients was 54.08 ± 6.33 years (mean ± standard deviation). Out of 50 patients studied, the number of true positive cases for Romhilt and Estes Point Score system were 14 and false negative cases were 26. The number of true negatives was 9 while one subject was found to be false positive for the test. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic efficacy of the test were calculated. The calculated sensitivity and specificity were 35% and 90% respectively (Fig. 1).

The positive predictive value was 93.33% whereas negative predictive value was 25.71%. The diagnostic efficacy of the test was calculated as 46%. Although prevalence of echocardiographic LVH was higher in women than in men, yet sensitivity of the Romhilt-Estes point score was marginally lower in

women (42.85% vs. 44.44%). Specificity was high in both sexes (100% in women and 83.33% in men).

Table. 1: Romhilt-Estes Point Score System

Any limb lead 'R' wave or 'S' wave ≥ 2.0 mV	3 Points
Sv ₁ or Sv ₂ ≥ 3.0 mV	3 Points
Rv ₅ to Rv ₆ ≥ 3.0 mV	3 Points
ST-T wave abnormality (no digitalis therapy)	3 Points
ST-T wave abnormality (digitalis therapy)	1 Points
P terminal force in V ₁ > 4mV-msec	3 Point
Left axis deviation	1 Points
Intrinsicoid deflection in V ₅ or V ₆ ≥ 50 msec	1 Point

score of 3 points = no LVH
 score of 4 points = probable LVH
 score of 5 points = LVH present

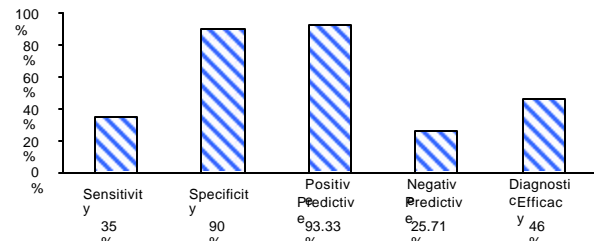


Fig. 1: Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Diagnostic Efficacy of Romhilt and Estes Point Score System of ECG in diagnosis of Left Ventricular Hypertrophy using Echocardiogram as the Gold Standard

DISCUSSION

ECG criteria for LVH, particularly those that are heavily reliant on voltage criteria, may result from abnormal thickening of the LV free wall or ventricular septum, LV chamber dilatation or increased LV wall tension.²³⁻²⁵ Echocardiography provides direct information concerning LV wall thickness and chamber size. Increased LV mass is also used as a diagnostic standard because the formula takes into consideration LV wall thickness and diastolic dimension presumably defining LV hypertrophy more accurately than increased LV wall thickness or LV enlargement alone.²⁵

The point scoring of Romhilt-Estes had 60% sensitivity and 98% specificity when the electrocardiogram was compared with findings at necropsy by the scientists Romhilt and Estes.²⁶ The same study used in its majority as population samples cases of serious cardiac disease, with large values of ventricular mass that could have led to overestimation of the method's sensitivity. Our study revealed sensitivity in both sexes much lower than that presented by these authors. Specificity was high

(90%), similar to the findings in both sexes in our study. In the study by Casale et al,²⁷ sensitivity of the Romhilt-Estes criterion was 33%, similar to that found in the present work (35%). Specificity was high at 94%, quite near to the value calculated in our study. Okin et al²⁸ evaluated the point scoring in men, finding in comparison with the echocardiogram, a sensitivity of only 12%, with a specificity of 100% for the Romhilt-Estes criterion. Devereux et al²⁵ found a sensitivity of 34% and a specificity of 98% in the comparison with left ventricular mass shown by the echocardiogram, without differences between results for either sex. Sensitivity in that study was very close to sensitivity found in the present study.

We found that the sensitivity of the Romhilt-Estes point score system of ECG for echocardiographic LVH is marginally lower in women than in men, possibly because of attenuation of QRS voltage by the greater spatial separation of myocardium from precordial electrodes because of breast tissue in women. Consistent with this is the finding that precordial QRS voltage is lower in women than in men.²⁹ Similarly mastectomy results in increased QRS amplitude.³⁰ Diminished Electrocardiographic sensitivity in women might also be, in part, a result of less voltage generated by the female heart, which contains approximately 25% less wall mass than the male heart.³¹ The findings of this study suggest that the voltage threshold for defining LVH should be lower in women than in men.

The point scoring of Romhilt-Estes showed a low correlation with the echocardiogram, and also was a difficult method to apply, because it was dependent on a close subjective analysis, which may generate doubts and cannot always be regularly applied, as for instance, in atrial fibrillation.

However the sensitivity of ECG to detect LVH can be increased by adding Cornell Voltage criteria and Sokolow Lyons voltage criteria to Romhilt-Estes point score system.

REFERENCES

- Koren MJ, Devereux RB, Casale PN, Savage DD, Laragh JH. Relation of left ventricular mass and geometry to morbidity and mortality in uncomplicated essential hypertension. *Ann Intern Med* 1991;114:345-52.
- Casale PN, Devereux RB, Milner M, Zullo G, Harshfield GA, Pickering TG, et al. Value of echocardiographic measurement of left ventricular mass in predicting cardiovascular morbid events in hypertensive men. *Ann Intern Med* 1986;105:173-8.
- Levy D, Garrison RJ, Savage DD, Kannel WB, Castelli WP. Prognostic implications of echocardiographically determined left ventricular mass in the Framingham Heart Study. *N Engl J Med* 1990;322:1561-6.
- Levy D, Garrison RJ, Savage DD, Kannel WB, Castelli WP. Left ventricular mass and incidence of coronary heart disease in an elderly cohort: the Framingham Heart Study. *Ann Intern Med* 1989;110:101-7.
- The Guidelines subcommittee of the WHO/ISH Mild Hypertension Liaison Committee: 1993. Guidelines for the management of mild hypertension: memorandum from a World Health Organization International Society Hypertension meeting. *Hypertension* 1993;22:392-403.
- Devereux RB. Does increased blood pressure cause left ventricular hypertrophy or vice versa? *Ann Intern Med* 2000;112:57-8.
- Devereux RB, Reichek MD. Echocardiographic determination of left ventricular mass in men. Anatomic validation of the method. *Circulation* 1997;55:613-8.
- Messerli FH, Aepfelbacher FC. Hypertension and Left - Ventricular hypertrophy. *Hypertension* 1995;13:549-57.
- Okin PM, Roman MJ, Devereux RB, et al. Time - voltage area of the QRS for the identification of left ventricular hypertrophy. *Hypertension* 1996;27:251-8.
- Norman JE, Levy D. Improved electrocardiographic detection of echocardiographic left ventricular hypertrophy: results of a correlated data base approach. *J Am Coll Cardiol* 1995;26:1022-9.
- Levy D, Labib SB, Anderson KM, Christ iansen JC, Kannel WB, Castelli WP. Determinants of sensitivity and specificity of electrocardiographic criteria for left ventricular hypertrophy. *Circulation* 1990;81:815-20.
- Molloy TJ, Okin PM, Devereux RB, Kligfield P. Electrocardiographic detection of left ventricular hypertrophy by the simple QRS voltage-duration product. *J Am Coll Cardiol* 1992;20:1180-6.
- Okin PM, Roman MJ, Devereux RB, Kligfield P. Electrocardiographic identification of increased left ventricular mass by simple voltage-duration products. *J Am Coll Cardiol* 1995;25:417-23.
- Norman JE Jr, Levy D, Campbell G, Bailey JJ. Improved detection of echocardiographic left ventricular hypertrophy using a new electrocardiographic algorithm. *J Am Coll Cardiol* 1993;21:1680-6.
- Xie X, Liu K, Stamler J, Stamler R. Ethnic differences in electrocardiographic left ventricular hypertrophy in young and middle-aged employed American men. *Am J Cardiol* 1994;73:564-7.
- Crow RS, Prineas RJ, Rautaharju P, Hannan P, Liebson PR. Relation between electrocardiography and echocardiography for left ventricular mass in mild systemic hypertension (results from Treatment of Mild Hypertension Study). *Am J Cardiol* 1995;75:1233-8.
- Arnett DK, Rautaharju P, Crow R, Folsom AR, Ekelund LG, Hutchinson R, et al. Black-white differences in electrocardiographic left ventricular mass and its association with blood pressure (the ARIC study): Atherosclerosis Risk in Communities. *Am J Cardiol* 1994;74:247-52.
- Rautaharju PM, Zhou SH, Calhoun HP. Ethnic differences in ECG amplitudes in North American white, black, and Hispanic men and women: effect of obesity and age. *J Electrocardiol* 1994;27(suppl):20-31.
- Mosteller RD. Simplified calculation of Body Surface Area. *N Engl J Med* 1987;317(17):1098. Correspondence.
- Lam TK, Leung DT. More on simplified calculation of body-surface area. *N Engl J Med* 1988;318(17):1130.(letter).
- Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man. Anatomic validation of the method. *Circulation* 1977;55:613-8.
- Memon MA, Ishaq M, Kundi A, Shah SA, Habiba, Tasneem, et al. Echocardiographic correlation of left ventricular mass index in normotensive and hypertensive Pakistani population. *PJC* 2000;11(1):9-21.
- Nath A, Alpert MA, Terry BE, Kelly DL. Sensitivity and specificity of electrocardiographic criteria for left and right ventricular hypertrophy in morbid obesity. *Am J Cardiol* 1988;62:126-30.

24. Reichek N, Devereux RB. Left ventricular hypertrophy: relationship of anatomic, echocardiographic and electrocardiographic findings. *Circulation* 1981;63(6):1391-8.
25. Devereux RB, Casale PN, Eisenberg RR, et al. Electrocardiographic detection of left ventricular hypertrophy using echocardiographic determination of left ventricular mass as the reference standard. comparison of standard criteria, computer diagnosis and physician interpretation. *J Am Coll Cardiol* 1984; 3: 82-7.
26. Romhilt DW, Estes Jr. EH. A point-score system for the ECG diagnosis of left hypertrophy. *Am Heart J* 1968; 75: 752-8.
27. Casale PN, Devereux RB, Alonso DR, et al. Improved sex – specific criteria of left ventricular hypertrophy for clinical and computer interpretation of electrocardiograms: validation with autopsy findings. *Circulation* 1987; 75: 565-72.
28. Okin PM, Roman MJ, Devereux RB, et al. Electrocardiographic diagnosis of left ventricular hypertrophy by the time - voltage integral of the QRS complex. *J Am Coll Cardiol* 1994; 23: 133-40.
29. Levy D, Bailey JJ, Garrison RJ, Horton MR, Balkus SM, Lyons D, et al. Electrocardiographic changes with advancing age. *J Electrocardiol* 1987;20(suppl):44-7.
30. LaMonte CS, Freiman AH. The electrocardiogram after mastectomy. *Circulation* 1965;32:746-54.
31. Levy D, Savage D, Garrison RJ, Anderson KM, Kannel WB, Castelli WP. Echocardiographic criteria for left ventricular hypertrophy: The Framingham Heart Study. *Am J Cardiol* 1987;59:956-60.

Address for Correspondence

Dr. Waqas Hameed, Dept. of Physiology, Army Medical College, Abid Majeed Road, Rawalpindi

Email: waqham.yahoo.com