



ORIGINAL RESEARCH PAPER

General Medicine

A STUDY OF PERFORMANCE OF VARIOUS ELECTROCARDIOGRAPHY CRITERIA IN PATIENTS WITH LEFT VENTRICULAR HYPERTROPHY WITH HYPERTENSION AND VALVULAR HEART DISEASES

KEY WORDS:

Echocardiography; electrocardiography; left ventricular hypertrophy, hypertension .

Dr. B. Balasubramanyam*

M.D. Asst. Professor, Dept. Of General Medicine, SVRRGH, Tirupati. Dr.NTR University of Health sciences,Vijayawada. *Corresponding Author

Dr. S. Venkatesh

M.D. Junior Resident, Dept. Of General Medicine, SVRRGH, Vijayawada. Dr.NTR University of Health sciences,Vijayawada.

ABSTRACT

BACKGROUND: Left ventricular hypertrophy is a common condition that commonly affects morbidity and mortality from cardiovascular diseases, including congestive heart failure, myocardial infarction, and stroke. The ECG in the assessment of cardiac dimensions has lost its prominence in favor of imaging techniques that provide a multidimensional display of the heart, but secondary ST-T changes due to LVH, which are uniquely determined from the ECG, are known to increase the risk of cardiovascular morbidity and mortality. Considering the magnitude of LVH, the study is designed to correlate between three different ECG criteria of left ventricular hypertrophy in patients with hypertension and valvular heart diseases using echocardiography as a diagnostic standard.

OBJECTIVES: To identify the left ventricular hypertrophy and to compare relative sensitivity, specificity, accuracy, positive predictive value, the negative predictive value of echocardiography, and 12 lead ECG for detecting left ventricular hypertrophy in patients with hypertension and valvular heart diseases.

METHODOLOGY: The study was conducted on 100 patients at SVRRGH Hospital, Tirupati, during the years 2018 and 2019. Patients were divided into two groups the study group and the control group. Patients in the study group had echo evidence of LVH, whereas the patients in the control group had no echo evidence of LVH. After taking a full detailed history, all the patients were subjected to physical examination, ECG, and echo.

RESULTS: In the present study, the sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 35%, 47%, and 54% respectively in hypertensive patients. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 28%, 28%, and 42% respectively in patients with mitral regurgitation. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 50%, 75%, and 75%, respectively, in patients diagnosed with aortic regurgitation. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 40%, 40%, and 60%, respectively, in aortic stenosis patients. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 42%, 71%, and 85% respectively in combined valvular lesions.

CONCLUSION : This study shows that all the ECG criteria have low sensitivity but high specificity, so we cannot use ECG to rule out LVH in patients with hypertension and valvular heart diseases. ECG can still be recommended as a routine investigation for LVH in patients with hypertension and valvular heart diseases because of its cost-effectiveness and easy availability but should not be used to rule out LVH and it showed better sensitivity in detecting left ventricular hypertrophy only when it is severe.

INTRODUCTION

Left ventricular hypertrophy is a common condition that profoundly affects morbidity and mortality from cardiovascular diseases, including myocardial infarction, congestive heart failure, and stroke. The prevalence of LVH is on the rise, more alarming in the developing nations. The Framingham heart study suggested that 1 in 10 persons will have left ventricular hypertrophy in age 65 to 69¹. The study also stated that electrocardiogram diagnosed LVH was associated with a 3-5 fold increase of cardiovascular events with the higher risk ratios for cardiac failure and stroke. LVH is no longer considered as 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 failure².

The increase in left ventricular mass represents a final pathway towards the adverse effects on the cardiovascular system and higher vulnerability to complication³. The studies clarify a strong relation between left ventricular hypertrophy and adverse outcome and hence emphasize the clinical importance for its detection⁴. The ECG in the assessment of cardiac dimensions has lost its prominence in favour of imaging techniques that provide a multidimensional display of the heart, but secondary ST-T changes due to LVH, which are uniquely determined from the ECG, are known to increase the risk of cardiovascular morbidity and mortality⁵.

Today, a two-dimensional echocardiogram still demands considerably more time, cost, the technical skill of the

operator, and complexity of processing than routine 12 lead ECG. It may be expected that correlation with imaging techniques will improve the performance of the electrocardiogram in the assessment of cardiac anatomy by defining more accurately the limit of its capability.

More than 30 ECG indexes for the diagnosis of LVH have been described. Many of the proposed indexes have remained anecdotal, but others are commonly used⁶. Considering the magnitude of LVH, the study is designed to correlate three different ECG criteria of left hypertrophy using echocardiography as a diagnostic standard.

Study Design

This was a Hospital based Correlation study conducted in SVRRGH hospital, Tirupati, from August 2018 to October 2019. The study Group and control group comprised of patients who have echocardiographic evidence of LVH and patients who had no echo evidence of LVH respectively. Detailed History was taken, Physical examination was done and following investigations like ECG, 2D ECHO, Chest X-Ray, Random Blood Sugar, Serum Creatinine, Blood Urea, Complete Blood Picture, Lipid Profile and Urine Examination were done. **The electrocardiographic variables to be recorded are** a) The voltage of R, S or Q waves in all the leads, b) ST-T changes, c) Axis, d) Duration of QRS complexes in limb leads, e) Intrinsicoid deflection in V5, V6 and f) P' terminale in V1.

Electrocardiographic criteria used in this study are:

i. Sokolov-Lyon Index: S in V1, +R in V5 or V6 > 35mm

- ii. Romhilt -Estes point score system:
- iii. Total QRS voltage criteria

Inclusion Criteria:

1. Patients with echocardiographic evidence of Valvular heart diseases.
2. Hypertension.
3. Patients with echocardiographic evidence of Coarctation Of Aorta.
4. Patients with echocardiographic evidence Ventricular Septal Defect.

Exclusion Criteria:

1. Myocardial Infarction.
2. Bundle Branch Block.

Statistical Methods

The statistical tests are diagnostic validity tests (specificity and sensitivity). Kappa measures of the agreement have been performed.

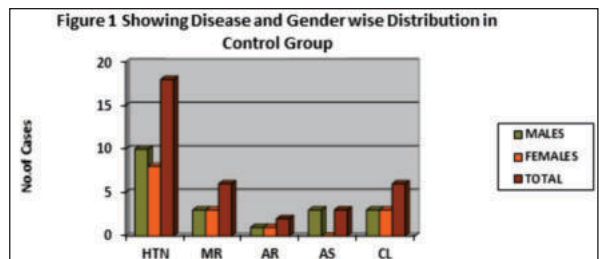
RESULTS

In this study, 100 patients were enrolled. Out of 100 patients, 61 were male, and 39 were female. Among the study subjects, 60 were hypertensive, 13 patients had pure MR, six were suffering from pure AR, eight had pure AS, and 13 were having combined lesions (MR, AR, AS, and AR). The patients were divided into two groups, the study group, and the control group. Following is the disease wise breakup of patients in the study and control groups, as depicted in table 1 and figure 1 respectively:

Table 1: Disease Wise And Genderwise Distribution Of Patients In Study Group

S.No.	Disease	Male	Female	Total
1	Hypertension	27	15	42
2	Pure Mitral Regurgitation	4	3	7
3	Pure Aortic Regurgitation	3	1	4
4	Pure Aortic Stenosis	4	1	5
5	Combined lesions MR,AR,AS & AR	3	4	7
TOTAL		41	24	65

The study group patients had echocardiographic evidence of left ventricular hypertrophy, i.e., the average of septal and posterior wall thickness > 1.2 cm. This study group comprised 65 patients, out of whom 41 were males and 24 females. The control group patients had no echocardiographic evidence of left ventricular hypertrophy, i.e., the average of sums of septal and posterior wall thickness was < 1.1 cm. The control group consisted of 35 patients, out of whom 20 were males and 15 females.



Disease Wise Performance Of Ecg Criteria For Diagnosis Of Lvh:

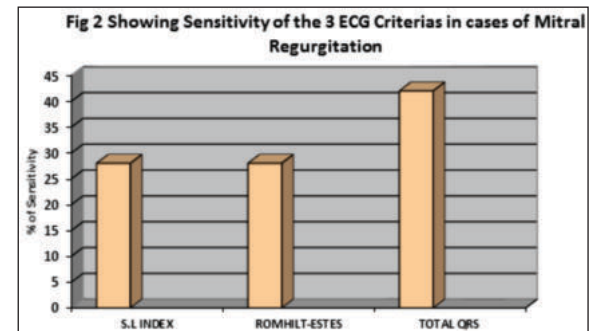
1) Hypertension: Out of 65 patients in the study group as depicted in table 2, 42 patients had hypertension and echo LVH. The left ventricular wall thickness in the echo recording ranged from 1.2-1.7cm. The Sokolov-Lyon criteria detected only 15 of them. The Romhilt -Estes point score system with 4 points detected 20. Whereas the total QRS voltage criteria

detected 23 patients with LVH. **Sokolov-Lyon index** – Out of 42 hypertensive patients with echo evidence of LVH, the Sokolov-Lyon Index (SVI + RV5 V6) recorded the lowest of 16mm and the highest of 52mm. In this study, out of 60 patients with hypertension, 42 patients have echo evidence of LVH. Out of these 42 patients, S.L criteria detected 15 patients. So the Sensitivity for hypertension with the S.L index is 35%. The numbers of false-positive cases were 3. **The Romhilt-Estes Point score system** – The maximum point score was 9. In this study, out of 60 patients with hypertension, 42 had echo evidence of LVH. Out of these 42 patients, The Romhilt -Estes system detected 20 patients. So the Sensitivity for hypertension with The Romhilt -Estes system is 47%. The numbers of false-positive cases were 3. **Total QRS voltage criteria-** In the total QRS voltage criteria, the voltage ranged from 120-248. In this study, out of 60 patients with hypertension, 42 had echocardiographic evidence of LVH. Out of these 42 patients, the total QRS voltage criteria detected 23. So the sensitivity for hypertension with total QRS voltage criteria is 54%. The no. of false-positive cases was 1.

Table 2: Sensitivity For Hypertension Of Various Ecg Criteria

Criteria	Sensitivity for Hypertension
Sokolov-Lyon index	35 %
The Romhilt -Estes system	47 %
Total QRS voltage criteria	54 %

2) Mitral regurgitation (Pure) – Out of 65 patients in the study group, there were seven patients with Mitral regurgitation (pure) and echo LVH as shown in figure 2. The left ventricular wall thickness in the echo recording ranged from 1.3-1.5cm. The Sokolov-Lyon criteria detected only 2 of them. The Romhilt -Estes point score system with 4 points detected 2. Whereas the total QRS voltage criteria detected three patients with LVH. **The Sokolov-Lyon index-** The Sokolov-Lyon Index (SVI + RV5 V6) recorded the lowest of 25mm and the highest of 42mm in 7 patients of Mitral regurgitation (pure) with echo evidence of L.V.H. In this study, out of 13 patients with Mitral regurgitation (pure), 7 has echocardiographic evidence of LVH. Out of these seven patients, S.L Index detected 2. So the Sensitivity for Mitral regurgitation (pure) with the S.L index is 28%. The no. of false-positive cases was 1. **The Romhilt-Estes Point score system** – The maximum point score was 7. In this study, out of 13 patients with Mitral regurgitation (pure), 7 had echocardiographic evidence of LVH. Out of these seven patients, The Romhilt -Estes system detected 2, so the Sensitivity for Mitral regurgitation (pure) with The Romhilt -Estes system is 28%. The no. of false-positive cases was 1. **Total QRS voltage criteria-** In the total QRS voltage criteria, the voltage ranged from 136-188 mm. In this study, out of 13 patients with Mitral regurgitation (pure), 7 had echocardiographic evidence of LVH. Out of these seven patients, the total QRS voltage criteria detected 3. So the Sensitivity for Mitral regurgitation (pure) with the total QRS voltage criteria is 42%. There was no false-positive case.



3) Aortic regurgitation (pure) – Among 65 patients in the study group there were only Four patients with Aortic regurgitation (pure) and echocardiographic LVH as shown in table 3. The left ventricular

wall thickness in the echocardiographic recording ranged from 1.2-1.5cm. The Sokolov-Lyon criteria detected only 2 of them. The Romhilt - Estes point score system with 4 points detected 3. Whereas the total QRS voltage criteria detected three patients with LVH. **The Sokolov-Lyon index** – The Sokolov-Lyon Index (SVI + RV5V6) recorded the lowest of 28mm and the highest of 56mm in 4 patients of Aortic regurgitation (pure) with echocardiographic evidence of LVH. In this study, out of 6 patients with Aortic regurgitation (pure), 4 had echocardiographic evidence of LVH. Out of these four patients, S.L Index detected 2, so the Sensitivity for Aortic regurgitation (pure) with the S.L index is 50%. The no. of the false-positive case was 1. **The Romhilt –Estes Point score system** –The maximum point score was 8. In this study, out of 6 patients with Aortic regurgitation (pure), 4 had echocardiographic evidence of LVH. Out of these four patients, The Romhilt – Estes system detected 3. So the Sensitivity for Aortic regurgitation (pure) with The Romhilt - Estes system is 75%. The false-positive case was only 1. **Total QRS voltage criteria**- In the total QRS voltage criteria, the voltage ranged from 166-240mm. In this study, out of 6 patients with Aortic regurgitation (pure), 4 had echocardiographic evidence of LVH. Out of these four patients, the total QRS voltage criteria detected 3. So the Sensitivity for Aortic regurgitation (pure) with the total QRS voltage criteria is 75%. There was no false-positive case.

Table 3: Sensitivity For Aortic Regurgitation (pure) Of Various Ecg Criteria

Criteria	Sensitivity for For Aortic regurgitation (pure)
Sokolov-Lyon index	50 %
The Romhilt -Estes system	75 %
Total QRS voltage criteria	75 %

4) Aortic stenosis (pure) - Out of 65 patients in the study group, there were only five patients with Aortic stenosis (pure) and echocardiographic LVH. The left ventricular wall thickness in the echocardiographic recording ranged from 1.3-1.5cm. The Sokolov-Lyon criteria detected only 2 of them. The Romhilt - Estes point score system with 4 points detected two, whereas the total QRS voltage criteria detected three patients with LVH. **The Sokolov-Lyon index** – The Sokolov-Lyon Index (SVI + RV5V6) recorded the lowest of 19mm and the highest of 62mm in 4 patients of Aortic stenosis (pure) with echocardiographic evidence of LVH. In this study, out of 8 patients with Aortic stenosis (pure), 5 had echocardiographic evidence of LVH. Out of these five patients, S.L Index detected 2. So the Sensitivity for Aortic stenosis (pure) with the S.L index is 40%. The no. of false-positive cases was 2. **The Romhilt –Estes Point score system** – The maximum point score was 7. In this study, out of 8 patients with Aortic stenosis (pure), 5 had echo evidence of LVH. Out of these five patients, The Romhilt –Estes system detected 2. So the Sensitivity for Aortic stenosis (pure) with The Romhilt - Estes system is 40%. The no. of false-positive cases was 1. **Total QRS voltage criteria**- In the total QRS voltage criteria, the voltage ranged from 138-216mm. In this study, out of 8 patients with 5 had echocardiographic evidence of LVH. Out of these five patients, the total QRS voltage criteria detected 3. So the Sensitivity for Aortic stenosis (pure) with the total QRS voltage criteria is 60%. There was two false-positive case.

Combined lesions-

Out of 65 patients in the study group as shown in table 4, there were only seven patients with combined lesions and echocardiographic LVH. The left ventricular wall thickness in the echocardiographic recording ranged from 1.3-1.7cm. The Sokolov- Lyon criteria detected only 3 of them. The Romhilt - Estes point score system with 4 points detected 5, whereas the total QRS voltage criteria detected six patients with LVH.

The Sokolov-Lyon index – The Sokolov-Lyon Index (SVI + RV5V6) recorded the lowest of 32mm and the highest of 58mm in 4 patients of Combined lesions with echocardiographic

evidence of LVH. In this study, out of 13 patients with combined lesions, 7 had echocardiographic evidence of LVH. Out of these seven patients, S.L Index detected 3. So the Sensitivity for Combined lesions with the S.L index is 42%. The no. of false-positive cases was 1. **The Romhilt –Estes Point score system** –The maximum point score was 8. In this study, out of 13 patients with combined lesions, 7 had echocardiographic evidence of LVH. Out of these seven patients. The Romhilt – Estes system detected 5. That gives the Sensitivity for Combined lesions with The Romhilt -Estes system is 71%. The no. of false-positive cases was 2. **Total QRS voltage criteria**- In the total QRS voltage criteria, the voltage ranged from 149-300mm. In this study, out of 13 patients with combined lesions, 7 had echocardiographic evidence of LVH. Out of these seven patients, the total QRS voltage criteria detected 6. So the Sensitivity for Combined lesions with the total QRS voltage criteria is 85%. There was one false-positive case.

Table 4: Sensitivity For Combined Lesions Of Various Ecg Criteria

Criteria	Sensitivity for Combined lesions
Sokolov-Lyon index	42 %
The Romhilt -Estes system	71 %
Total QRS voltage criteria	85 %

DISCUSSION

In this study, 100 patients were enrolled. Out of 100 patients, 61 were male, and 39 were female. Among the study subjects, 60 were hypertensive, 13 patients had pure MR, six were suffering from pure AR, eight had pure AS, and 13 were having combined lesions (MR, AR, AS, and AR). The patients were divided into two groups, the study group, and the control group. The study group patients had echocardiographic evidence of left ventricular hypertrophy, i.e., the average of septal and posterior wall thickness > 1.2 cm. This study group comprised 65 patients, out of which 41 were males and 24 females. The control group patients had no echocardiographic evidence of left ventricular hypertrophy, i.e., the average of sums of septal and posterior wall thickness was < 1.1 cm. The control group consisted of 35 patients, out of whom 20 were males and 15 females. In this study, the prevalence of hypertension in cases is 65% (42 out of 65 cases). Out of 42 patients, the prevalence in males and females was 27 (64%) and 15 (36%), respectively. In the control group, the prevalence of hypertension is 5% (18 out of 35 cases).

Table 5: Prevalence Of Hypertension In Lvh Patients Compared With Other Studies

S.No	STUDY	MALES %	FEMALES %
1	Wei Zhang et al (2019) ⁶	46	54
2	Kumar Narayan et al (2014) ⁷	58	42
3	Jin Kyu Park et al (2012) ⁸	50	50
4	Present study	64	36

In the present study, the sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 35%, 47%, and 54% respectively in hypertensive patients. According to Jern S et al. (1997), the sensitivity of the Sokolow-Lyon index in diagnosing Left Ventricular Hypertrophy was found to be 68%.⁹ The sensitivity of voltage criteria in detecting Left ventricular hypertrophy was also found to be 68%. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 28%, 28%, and 42% respectively in patients with mitral regurgitation. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 50%, 75%, and 75%, respectively, in patients diagnosed with aortic regurgitation. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 40%, 40%, and 60%,

respectively, in aortic stenosis patients. The sensitivity of the Sokolow-Lyon Index, Romhilt Estes point scoring system, and voltage criteria was 42%,71%, and 85% respectively in combined valvular lesions.

Table 6 : Sensitivity Of Various Ecg Criteria According To Disease:

	S-L INDEX	R.E POINT SYSTEM	TOTAL QRS VOLTAGE
HYPERTENSION	35	47	54
MITRAL REGURGITATION	28	28	42
AORTIC REGURGITATION	50	75	75
AORTIC STENOSIS	40	40	60
COMBINED LESION	42	71	85

REFERENCES

1. Friedman A.J., et al., Accuracy of M-mode echocardiographic measurements of the left ventricle. *Am.J.Cardiol*,1982;99:716-720.
2. Devereux RB. Does increased blood pressure cause left ventricular hypertrophy or vice versa? *Ann Intern Med*,2000;112:57-8.
3. Devereux RB, Reichek MD. Echocardiographic determination of left ventricular mass in men; Anatomic validation of the method" *Circulation*, 1997;55:613-8.
4. Vakili B.A., Okin P.M., Devereux R.B., Prognostic implications of left ventricular hypertrophy". *Am Heart Journal*,2001;141:334-341.
5. Elena Martinova. et al., Automated Computer Analysis in Diagnosis of left ventricular hypertrophy by electrocardiography. *Journal of Electrocardiology*, 2007;40:S41- S42.
6. Wei Zhang et.al. Consistency of left ventricular hypertrophy diagnosed by electrocardiography and echocardiography: the Northern Shanghai Study. *Clin Interv Aging*. 2019; 14: 549-556. *Heart Rhythm*. 2014 Jun; 11(6): 1040-1046.
7. Kumar Narayanan et.al., Electrocardiographic Versus Echocardiographic Left Ventricular Hypertrophy and Sudden Cardiac Arrest in the Community.
8. Jin Kyu Park et.al. A Comparison of Cornell and Sokolow-Lyon Electrocardiographic Criteria for Left Ventricular Hypertrophy in Korean Patients. *Korean Circ J*.2012 Sep;42(9):606-613.
9. Jern S et.al. Assessment of left ventricular hypertrophy in patients with essential hypertension. *Blood Press Suppl*. 1997;2:16-23.