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"COMPARISON OF SENSITIVITY AND SPECIFICITY OF DIFFERENT STANDARD ECG CRITERIA FOR DIAGNOSING LEFT VENTRICULAR HYPERTROPHY"

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ABSTRACT Electrocardiography (ECG) has become the most common and the first investigation in case of any clinical suspicion of heart disease. The very next investigation is evaluation by echocardiography (ECHO/ Doppler). The ECHO/Doppler study not being readily accessible everywhere, effort has always been done to make the most out of ECG. One of the most important tool for diagnosis of left ventricular hypertrophy (LVH) is ECG. Nonetheless the sensitivity and specificity for LVH in ECG has been low. There are different methods to evaluate LVH with different levels of sensitivity and specificity. We thought of comparing the different methods for detection of LVH in ECG and draw a conclusion which one is the best among the different methods. We took up the present study in IMS & SUM Hospital located in eastern costal belt of India. 100 patients admitted to medicine ward clinically suspected to have LVH were included in the study. Patients with AV block, LBBB/ RBBB and acute myocardial infarction/ ischemia were excluded from the study. The results obtained by three different ECG criteria for LVH were compared with ECHO evidence of the same. Diagnostic validity (sensitivity and specificity) and kappa measurement of agreement were performed. The study has shown that ECG evidence of LVH is the lowest when interpreted by the commonest method (S in V_{1+} R in V_5 or V_6 whichever is greater). Whereas ECG evidence of LVH is highest by tedious and time tacking method (Total QRS voltage criteria) which is least used in clinical practice.

KEYWORDS : Left ventricular hypertrophy, Electrocardiography, Echocardiography.

1. INTRODUCTION

Left ventricular hypertrophy (LVH) is a condition that affects morbidity and mortality from cardiovascular diseases including myocardial infarction, Heart failure and stroke[1]. The two commonly used modalities to detect LVH are 2D-Echo and ECG. 2D-Echo demands substantially more time, cost, and technical skill of the operator and complexity of processing as compared to ECG. Also, ECG is much more readily available at all health care facilities, be it at primary health care level or emergency room at tertiary care hospital. Over the years, more than 30 ECG indices have been described for the diagnosis of LVH. As on this day, most of these indices are only of anecdotal value. A few of them are commonly used in routine daily practice[2].

The three ECG criteria now in use are:

Sokolow-Lyon voltage criteria[3](1949) (SL criteria):- The sum of voltage of S wave in VI and R wave in V5 or V6 (whichever is greater) totals more than 35 mm is suggestive of LVH. Also, there are other voltage criteria suggested by them. These are, R in V5 or V6 more than 26 mm, R wave in avL more than 11 mm, RI + S3 more than 25 mm etc. But SVl + RV5 or V6 is the most commonly used criteria.

Romhilt and Estes point score system[4](1968) (RE criteria)- Voltage criteria alone has low sensitivity and specificity for Diagnosis of LVH. To increase the sensitivity a point scoring system developed by Romhilt and Estes in 1968. A score of 4 indicates probability and a score of 5 or more indicates definite LVH. (Table 1)

Total QRS voltage criteria[5]**:** Roberts and Seigel proposed this criteria, sum total of QRS voltage (measured from peak of R up to the bottom of S or Q which ever is greater) of all the 12 conventional electrocardiographic leads to increase the sensitivity and specificity of the diagnosis of LVH. In most individuals over 30 years of age with normal sized heart, the total QRS voltage is less than 175 mm. Values of equal to or greater than 175 mm constitutes the criteria for LVH.

We carried out this study to assess the sensitivity and specificity of selected Electrocardiographic criteria (Sokolow and Lyon index [SL criteria], Romhilt-Estes point score [RE criteria] system and Total QRS Voltage criteria) of left ventricular hypertrophy using echocardiographic left ventricular hypertrophy as the standard. We also studied the possibility of ECG being more sensitive for LVH in some particular pathological conditions as compared to others.

2. MATERIAL AND METHODS

This study was conducted in IMS and SUM hospital Bhubaneswar. All patients were taken from medical wards. Suspected cases of LVH were taken up for Electrocardiography and also Echocardiography. The findings of LVH on 2D ECHO were compared with ECG findings of LVH by Sokolov Lyon voltage criteria, Romhilt Estes point score system and Total QRS Voltage criteria.

Patients were separated into two groups, the study group: comprised of patients who had echocardiographic features of of LVH. The control group: comprised of patients who had no echocardiographic evidence of LVH.

Inclusion criteria: Hypertension, Aortic regurgitation, Mitral regurgitation, Aortic stenosis, Coarctation of aorta, Ventricular septal defect.

Exclusion criteria: Cases of myocardial ischemia and infarction, Cases of bundle branch blocks.

The selected patients were studied in detail with history and physical examination.

A complete clinical examination was carried out in each patient with

particular reference to pulse, apex beat, and auscultatory findings in the mitral, tricuspid, pulmonary and aortic areas. Hypertension criteria was a systolic blood pressure recorded >140mmHg and or diastolic pressure > 90mmHg on 3 different occasions. ECG, Echocardiography and chest X-ray were done.

PROTOCOL

Electrocardiogram – Conventional 12-lead electrocardiogram was done in all patients. The ECG criterias used for LVH are:

Sokolov - Lyon Index: S in V_1 or V_2 R in V_5 or V_6 whichever is greater.

Romhilt - Estes point score system: A score of 4 indicates probability and a score of 5 or more than 5 indicates definite LVH.(Table 1)

Table 1: A score of 4 indicates probability and a score of 5 or more than 5 indicates definite LVH.

1	R or S in limb leads ≥20 mm or S in V1, V2, or V3 ≥25 mm or R in V4, V5 or V6 ≥25 mm	3 points
2	ST-T changes (without digitalis) (With digitalis)	3 points 1 point
3	'P' terminal force in V1 ≥1mm in depth or more than 0.04 sec.	3 points
4	Left axis deviation of -15˚or more	2 points
5	QRS interval 0.09 sec. or more	1 point
6	Intrinsicoid deflection in V5, V6 0.04 sec. or more	1 point
	TOTAL	13 Points

Total QRS voltage criteria: Sum total of QRS voltage (measured from peak of R up to the bottom of S or Q which ever was greater) of all the 12 conventional electrocardiographic leads, The normal value is 174mm. Any value above this will be significantly indicating left ventricular hypertrophy.

Echocardiographic studies: Combined M-mode and 2DEcho studies were performed in left decubitus position with slight elevation of the head. Comprehensive two-dimensional tomographic planes were employed with multiple parasternal views of the left ventricle in long and short axis, apical four chamber and long axis views and subcostal four chamber and short axis views.

Measurement: The left ventricular posterior and septal wall thickness were measured at the time of atrial depolarisation before the onset of a notch. The average of sum of septal and posterior wall thickness above 1.1 cm was taken as evidence of left ventricular hypertrophy[6]. After obtaining results of electrocardiogram and echocardiography statistical tests were performed which are, Diagnostic validity tests (specificity and sensitivity), Kappa measure of agreement. Sensitivity and specificity were calculated by the standard formulae (Table 2).

Table 2: Sensitivity and specificity of electrocardiogram and echocardiography.

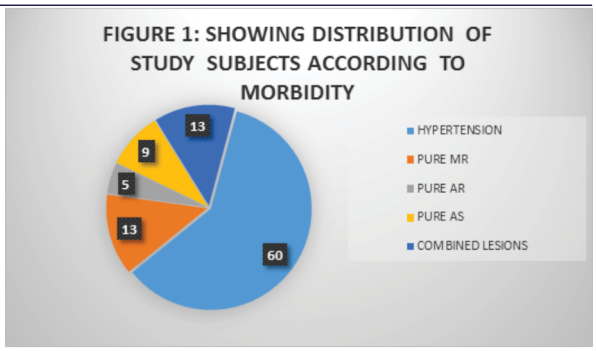
		Echocardiogram		
Electrocardiogram		+	-	
	+	a (true positive)	b (false positive)	a + b
	-	c (false negative)	d (true negative)	c +d
		a + c	b + d	

$$\text{Sensitivity} = \frac{a\ (\text{True positive})}{a+c\ (\text{True positive} + \text{False negative})} \times 100$$

$$\text{Specificity} = \frac{d\ (\text{true negative})}{b+d\ (\text{false positive}+\text{true negative})} \times 100$$

1. OBSERVATION AND ANALYSIS OF RESULTS

In this study 100 patients were enrolled. Out of them 67 were male and 33 were female. The patients were divided into the study group and the control group. Among the study subjects 60 were hypertensive, 13 patients had pure Mitral regurgitation (MR), 5 had pure Aortic regurgitation (AR), 9 had pure Aortic stenosis (AS) and 13 had combined lesions (MR, AS and AR) (Figure 1).



The study group patients had echocardiographic evidence of LVH in 67 patients, Outof these 67 electrocardiographic criteria like The Sokolov-lyon index could diagnose only 23 patients, sensitivity (34%), specificity (82%), PPV (79%), NPV (38%), accuracy (50%) and Kappa measure of agreement was 0.12. Romhilt - Estes point score system was positive in 29 patients, sensitivity (49%), specificity (75%), PPV (80%), NPV (42%), accuracy (58%) and Kappa measure of agreement was 0.20 for 4 point score and sensitivity (43%), specificity (78%), PPV (80%), NPV (40%), accuracy (55%) and Kappa measure of agreement was 0.17 for 5 point score. Total QRS voltage criteria could diagnose 39 of these patients, sensitivity (58%), specificity (90%), PPV (92%), NPV (51%), accuracy (69%) and Kappa measure of agreement was 0.50.(Table 3)

Table 3: Senstivity & specificty, accuracy, positive predictive value, negative predictive value and kappa measure of agreement of different electrocardiographic criteria for diagnosing LVH

Sl N	ECG Criteria	Sensitivity %	Specificity %	Accuracy %	PPV %	NPV %	Kappa Measure of agreement
1	S.L Index	34	82	50	79	38	0.12
2	R.E point score-4point	49	75	58	80	42	0.20
	5 point	43	78	55	80	40	0.17
3	Total QRS	58	90	69	92	51	0.5

Out of 42 patients with Hypertension, LVH was detected by SL criteria in 15, by RE criteria in 16 and Total QRS Voltage criteria in 23. For 8 patients with pure Mitral Regurgitation (MR), LVH was detected in only 2 by all the three ECG criteria. Out of 4 patients with Aortic Regurgitation (AR) SL criteria detected LVH in 2, RE criteria and Total QRS voltage criteria detected 3. Out of 7 patients having pure Aortic stenosis (AS) SL criteria detected 2, RE criteria detected 3, Total QRS voltage criteria detected 4. However out of the 7 patients with combined valvular lesions and ECHO evidence LVH, SL criteria detected LVH in 3, RE criteria detected in 5, Total QRS voltage criteria detected in 6 cases. Thus it was noted that although various ECG criteria are poor detectors of LVH in case of single valvular disease, the detection of LVH is quite high in case of combined valvular disease. For combined valvular disease the SL criteria detected 43%, RE criteria detected 71% and Total QRS voltage criteria 86%.(Table 4)

Table 4: Table showing sensitivity of various ECG criteria according to disease

	S-L Index	R. E Point System	Total QRS Voltage Criteria
Hypertension	36%	38%	55%
Mitral Regurgitation	25%	28%	28%
Aortic Regurgitation	50%	75%	75%
Aortic Stenosis	28%	43%	57%
Combined Lesion	43%	71%	86%

4. DISCUSSION

Presence or absence of LVH does matter a lot in assessing the risk factors and management plan in various cardiovascular diseases. Left ventricular mass increases in conditions like hypertension, some cardiomyopathies and a number of valvular diseases. Especially the ECG diagnosis of LVH becomes quite erroneous if electrically inactive fibrous tissue exists or conduction defects are there, especially in the older age group. This is the reason various methods have been

tried to establish LVH with higher sensitivity and specificity. Although echocardiography has proved to be the gold standard it is not available at primary health care level and also it is not cost effective. Therefore ECG has remained a tool in clinical practise for diagnosis of LVH. The earliest method (Sokolow lyon criteria) for detection of LVH in ECG was found to have less sensitivity and specificity. Other methods have been evolved to improve LVH sensitivity and specificity by ECG over the period of time. With this background we took up the present study to compare the sensitivity and specificity of different criteria in use today for diagnosis of LVH as compares to findings of 2DECHO and conclude which method is best.

Sokolow Lyon ECG criteria Reichek & Devereux[7] (1981) found the sensitivity (21%) and specificity (95%) whereas Norman et al[8] (1995) found sensitivity (30%) and specificity (86%) by the same method and also the work in 1998 Denarie et al[9] found sensitivity (20%) and specificity (90%), Gurpreet singh et al[10] (2017) reported sensitivity (38%) and specificity (75%) but our present study established a sensitivity of (34%) and specificity of (82%).

Romhilt-Estes ECG point score system Reichek & Devereux[7] (1981) found the sensitivity (50%) and specificity (95%) whereas Kansak S.[11] (1983) found sensitivity (57%) and specificity (81%) , Gurpreet singh et al[10] (2017) reported sensitivity (47%) and specificity (75%) and our present study established a sensitivity of (34%) and specificity of (82%).

Total QRS Voltage of ECG criteria Odom et al[12] (1986) found the sensitivity (70%) and specificity (90%) whereas Christian Jaggy et al[13] (2000) found sensitivity (42%) and specificity (78%) , Gurpreet singh et al[10] (2017) reported sensitivity (67%)and specificity (93%) and our present study established a sensitivity of (34%) and specificity of (82%).

Kappa measure of agreement was found to be 0.12 by Sokolov Lyon index, for Romhilt-Estes point score system was 0.20 when a score of 4 points taken as diagnostic and 0.17 when a score of 5 point taken as diagnostic, but in the Total QRS voltage criteria the Kappa measurement of agreement was found to the best that is 0.50.

Our study definitely derives that the Sokolov Lyon Index i.e , S in V_1 plus R in V_5 or V_6 whichever is greater , is an easy and quick method for forming an opinion for LVH. But the Total QRS voltage criteria i.e the sum total QRS voltage in all 12 leads is a little more time taking but much more reliable method of diagnosing LVH. Hence endeavour should always be made by the clinician to use the Total QRS voltage criteria, by using the calculator in mobile phone which will take much less time than the traditional system and it will give a diagnosis of LVH with much more reliability.

5. CONCLUSION

The study was carried out on 100 patients for finding the role played by electrocardiogram in the diagnosis of left ventricular hypertrophy. The best sensitivity was 58% for Total QRS voltage criteria whereas the least sensitivity was for S.L criteria which were 34%. Specificity was high for all the criteria, which were in the range of 82% for S L Index to 90% for Total QRS voltage criteria. Our findings suggest that all the ECG criteria for diagnosing LVH have a high specificity but low sensitivity. However, ECG can be used to assess presence of left ventricular hypertrophy with reasonable certainty by Total QRS Voltage criteria where Echocardiography is not available.

Conflict of Interest

The authors declare that there is no conflict of interest.

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