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Original Article

Internal Medicine Section

Electrocardiography and Echocardiography Correlation in Patients of Left Ventricular Hypertrophy

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ABSTRACT

Introduction: Electrocardiography (ECG) is the most common investigation for evaluation of Left Ventricular Hypertrophy (LVH), an important parameter of cardiovascular morbidity and mortality. This can also be evaluated by Echocardiography (Echo), which is superior to ECG but costlier, thus a major constraint in rural set ups.

Aim: To correlate the relationship of ECG and Echocardiography for the diagnosis of left ventricular hypertrophy and to find out sensitivity and specificity of various electrocardiographic criteria.

Materials and Methods: A total of 500 patients showing left ventricular hypertrophy by any of the mentioned ECG criteria, were enrolled in the study. Eight ECG criteria (Sokolow Lyon index, Romhilt Estes point score system, Talbot Criteria, Roberts's criteria, Cornell Criteria, McPhie criteria, Casale criteria and Criteria of Koitos & Spodick) and Echocardiogram were taken into account for the diagnosis. The statistical tests were performed using SPSS version 10.0. Diagnostic validity tests such as sensitivity, specificity Positive Predictive Value (PPV), Negative Predictive Value (NPV) and diagnostic accuracy were calculated.

Results: Out of 500 patients, 270 (54%) had LVH on Echo which was the gold standard investigation for the diagnosis of LVH in this study. Sokolow Lyon criteria showed sensitivity of 77.78%, specificity of 60.87%, PPV of 70%, NPV of 70% and accuracy of 70%. Comparison of Combined or either one of Sokolow Lyon and Romhilt Estes point score system on ECG with Echo for LVH showed sensitivity of 100%, specificity 60.87%, PPV 75%, NPV 100% and diagnostic accuracy of 82%.

Conclusion: Adding two, three or four criteria except Sokolow Lyon and Romhilt Estes point score system does not increase the diagnostic efficacy of the electrocardiography for left ventricular hypertrophy.

Keywords: Correlation, Diagnosis, Electrocardiography criteria, Echocardiography

INTRODUCTION

Left Ventricular Hypertrophy (LVH) is a common condition that profoundly affects morbidity and mortality like coronary artery disease, congestive cardiac failure, stroke, ventricular arrhythmias and sudden cardiac death [1]. The Framingham heart study suggested that LVH was associated with a 3-5 fold increase of cardiovascular events with the greater risk for cardiac failure and stroke [2].

The 12 lead ECG is the most common investigation available for the diagnosis of LVH as it is cost effective and convenient with reliable probability [3,4]. Nowadays, Echo has become most important noninvasive diagnostic tool for the evaluation of heart morphology and its haemodynamics [3]. Echocardiography is the gold standard for the diagnosis of LVH. Lack of specialisation, technical difficulties, cost of machine and investigation prices makes thing difficult for the use of echo to diagnose LVH as the first choice in rural setting. At least 30 ECG criteria have been used in past 10 years to diagnose LVH, still, it was not clear which ECG criterion is better over other in diagnosing LVH [4,5].

This study had been planned to compare two or more than two ECG criteria to find out the best ECG indicator for the diagnosis of LVH in a rural teaching hospital keeping echo as gold standard as well as to find out sensitivity and specificity of various electrocardiographic criteria.

MATERIALS AND METHODS

In this cross-sectional study, 500 subjects were taken using simple random sampling method, from August 2015 to August 2017. These patients were admitted to the Department of Medicine, Jawaharlal Nehru Medical College, Wardha, Maharashtra, India. The study received approval of the Institutional Ethics Committee [DMIMS (DU)/IEC/2014-15/815]. Patients on which echocardiography could not be performed and patient having poor Echo window were excluded from the study.

Sample size was calculated by using formula:

$$N=(Z^2\times P\times(1-P))/d^2$$

Z^2=table value of alpha error from Standard Normal Distribution table=1.96*1.96=3.84. Power (P)=0.05 (1-P)=0.95. Precision error of estimation (d)=2%. $N=(1.96^2\times0.05\times0.95)/0.02^2=465.6$, Hence the sample size of 500 patients was taken for the study.

The nature of study was explained to the participants and written informed consent was taken from the participants in English and Marathi language. 12-lead Electrocardiography was performed by using BPL Cardiolinear 2100 view electrocardiography machine. Electrocardiographs were recorded after a supine resting period of at least 20 minutes.

Eight ECG criteria (Sokolow Lyon index, Romhilt Estes point score system, Talbot Criteria, Roberts's criteria, Cornell Criteria, McPhie criteria, Casale criteria and Criteria of Koitos & Spodick) were considered for the diagnosis.

In Romhilt-Estes point score criteria, there are multiple ECG criteria. [RE1: Amplitude: any of these three=3 points. (Largest R or S in the limb leads ≥20 mm; S wave in V1 or V2 ≥30 mm; R wave in V5 or V6 ≥30 mm). RE2: ST-T change of typical LV strain=3 points. RE3: Left atrial involvement (Terminal negativity of P in V1 >1 mm and longer than 40 milliseconds)=3 points. RE4: Left axis deviation -30 or more=2 points. RE5: QRS duration ≥90 milliseconds=1 point. RE6: Intrinsicoid deflection in V5, V6 ≥50 ms=1 point)]. Total 13 points are there out of which 4 points are suggestive of probable and 5 or more points are diagnostic of LVH [6].

In Sokolow Lyon index, LVH is calculated by the amplitude of S wave in lead V1 plus amplitude of R wave in lead V5 or V6 and if it is more than 35 mm it is significant for the diagnosis of LVH [7].

In Talbot criteria, R wave in lead aVL equal to or more than 11 mm or R in aVL equal to or more than 13 mm with left axis deviation is suggestive of LVH [8].

Cornell criteria are voltage criteria for the diagnosis for LVH, which is different for male and females. S wave in V3 plus R wave in aVL should be more than 24 mm in male, and for females S wave in V3 and R wave in aVL should be more than 20 mm [8].

Robert criteria are also called as total 12 lead voltage criteria, in this total amplitude of all the leads is greater than 175 mm then it is significant for the diagnosis of LVH [9].

McPhie criterion considers tallest R wave amplitude plus deepest S wave amplitude in any precordial lead. If the total exceeds 4.5 mV i.e. 45 mm LVH should be considered [10].

The Casale criterion is different for male and female. For the diagnosis of LVH if R wave in aVL plus S wave in V3 is greater than 2.8 mV or 28 mm in male, and in female if it is 2.0 mV or 20 mm. This criterion is also called as modified Romhilt criteria [11].

Koitos and Spodick criteria states that if R wave amplitude in lead V6 is greater than R wave amplitude in lead V5 then it is significant for LVH [12].

Echocardiography was performed by using Philips HD 11 XE echocardiography machine with multi-frequency 2-4 megahertz probe. Transthoracic Doppler echocardiographic examinations were conducted and evaluated by specially trained and certified physicians. All echocardiographs underwent the same dedicated study certification procedures. All the examiners for the echocardiography had no prior knowledge of the study they were blinded as far as the study was concerned. Parasternal long axis view was taken and interventricular septal thickness is then measured in diastole. Left ventricular hypertrophy was measured via Interventricular Septal Thickness (IVST) where IVST equals to or greater than 11 mm is suggestive of left ventricular hypertrophy. Left ventricular hypertrophy was divided in mild hypertrophy (11-13 mm), moderate hypertrophy (14-16 mm) and severe hypertrophy (17 and above) [5]. Patients were also screened for Body Mass Index (BMI) and waist by hip ratio.

STATISTICAL ANALYSIS

Statistical analysis was done by using descriptive and inferential statistics using Chi square test, binary classification and multiple regression analysis and software used in the analysis were SPSS 17.0 version and GraphPad Prism 6.0 version and $p<0.05$ is considered as level of significance.

RESULTS

Out of the total 500 patients, the mean age of the study population was 58.56 years (SD,13.43). All base line characteristics of the patients are shown in [Table/Fig-1].

Sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and diagnostic accuracy was highest for Romhilt-Estes Point Score as depicted in [Table/Fig-2]. Comparison of combined or either one of Sokolow Lyon and Romhilt Estes point score system on ECG with Echo for LVH revealed the following- Sensitivity=100%, Specificity=60.87%, Positive Predictive Value=75%, Negative Predictive Value=100%, Diagnostic Accuracy=82% [Table/Fig-3].

Comparison by any Two, Three, Four Criteria on ECG with ECHO for LVH are shown in [Table/Fig-4]. Multiple regression analysis of all the electrocardiographic criteria for left ventricular hypertrophy with interventricular septal thickness showed that all criteria except for Koitos and Spodick criteria correlate significantly with interventricular septal thickness as shown in [Table/Fig-5].

Parameters	Mean±SD
Age	58.56±13.43
Gender: Male	255 (51%)
Female	245 (49%)
BMI (kg/m^2)	21.07±3.49
WHR	0.90±0.05
Systolic BP (mmHg)	134.72±16.52
Diastolic BP (mmHg)	82.32±8.89
LVH on Echo	270 (54%)

[Table/Fig-1]: Baseline characteristics of study population.

Criteria	Sensitivity	Specificity	PPV	NPV	Accuracy
Sokolow Lyon	77.78	60.87	70	70	70
Romhilt-Estes point score	81.48	69.57	75.86	76.19	76
Talbot criteria	51.85	60.87	60.87	51.85	56
Cornell voltage	55.56	60.87	62.50	53.85	58
Robert criteria	81.48	39.13	61.11	64.29	62
McPhies criteria	51.85	65.22	63.64	53.57	58
Casale criteria	48.15	73.91	68.42	54.84	60
Koitos and Spodick	44.44	56.09	54.30	46.24	49.8

[Table/Fig-2]: Comparison of sensitivity and specificity of all ECG criteria.

Sokolow Lyon and/or Romhilt Estes point score	ECHO		Total	χ^2-value
	LVH on ECHO positive	No LVH on ECHO negative		
ECG positive	270	90	360	228.30 p=0.0001,S
ECG negative	0	140	140	
Total	270	230	500	

[Table/Fig-3]: Comparison of Combined or either one of Sokolow Lyon and Romhilt Estes point score system on ECG with Echo for LVH.

Criteria	Sensitivity	Specificity	PPV	NPV	Accuracy
Two criteria	18.89	69.57	42.15	42.22	42.20
Three criteria	21.85	100	100	52.15	42.20
Four criteria	7.40	95.65	66.67	46.81	48

[Table/Fig-4]: Comparison by any Two, Three, Four Criteria on ECG with ECHO for LVH.

Variables	Unstandardized coefficients		Standardised coefficients	t	p-value
	B	Std. error	Beta		
IVST	19.23	0.387			
Sokolow Lyon	-1.49	0.162	-0.395	9.233	0.0001*
Romhilt-Estes point score	-1.37	0.155	-0.366	8.886	0.0001*
Talbot criteria	1.30	0.497	0.350	2.622	0.009*
Cornell voltage	-2.31	0.474	-0.624	4.879	0.0001*
Robert criteria	-2.28	0.161	-0.555	14.256	0.0001*
McPhies criteria	1.91	0.244	0.513	7.833	0.0001*
Casale criteria	-1.61	0.195	-0.422	8.251	0.0001*
Koitos and Spodick	-0.03	0.265	-0.008	0.116	0.908#

[Table/Fig-5]: Multiple Regression Analysis.
* Significant; #Non significant

DISCUSSION

In this study, it was found that combination or either one of the Sokolow Lyon and Romhilt Estes point score system for the diagnosis of LVH had very high sensitivity and negative predictive value. So absence of either any of these criteria can be very well used to rule out the diagnosis LVH. However because of low specificity of combination or either of these two criteria, presence of LVH by either of these two criteria on ECG should be confirmed by Echo.

Sokolow Lyon criteria showed higher sensitivity as compared to study done by Sosnowski M et al., [13] which showed sensitivity of 61%; this could be because of small number of the patients in the later study. Also, they had studied only the patients suffering from anterior wall myocardial infarction which leads to myocardial necrosis. This may be responsible for low voltage or decapitation of R waves on electrocardiography making detection of LVH on ECG more difficult. Specificity, positive predictive value, negative predictive value of this study correlates with other previously done studies [14-18]. Cornell criteria showed much higher sensitivity as compared to previous study by Martin TC et al., [19]. This could be because of the fact that this study was performed on Afro-Caribbean population, it was mentioned in the study itself that the sensitivity of this criteria were worse in African and it was very poor in Afro-Caribbean population.

Specificity in this study was 60.87% less than specificity found in the study conducted by Sosnowski M et al., which showed specificity of 83.7% [13]. The possible explanation for the differences in specificity between present and previous studies could be explained by the difference in the selection of the study subjects. Present study had included only patients of anterior wall myocardial infarction and other studies also had patients of systemic hypertension and other medical conditions. However, in present study, the present authors included patients solely based on their ECG criteria for LVH. Robert criteria is one of the most sensitive criteria for LVH on ECG in present study but its specificity was low. This criteria can be taken as a good indicator for LVH but echocardiography should be performed to confirm the finding LVH especially in the individual with low body mass index and normotensive individuals. Jaggy C et al., [14], Martin TC, et al., [19] and Venugopal K, et al., [20] showed less sensitivity and high specificity as compared to present study. This could be because of the fact that Robert voltage criteria measure voltage tallest R wave and deepest S wave in the QRS complexes in all the 12 leads. Thin build patients will have high R waves and deep S waves due to increase conductance through thin built as compared to obese or fat patients who have thick chest wall.

The mean BMI in present study was low (21%) as compared to a previous study by Jaggy C et al., which had high mean BMI of 25.6 [14]. Also, all the previous mentioned studies had exclusively included hypertensive patients which could have led to high specificity in these studies. Present study had not considered hypertension as the only inclusive criteria in the study which could be responsible for low specificity in the present study.

Combination or either one of Sokolow Lyon index and Romhilt Estes point score system was most accurate for the diagnosis of left ventricular hypertrophy on electrocardiography with comparison to the gold standard echocardiography. With the combination of these two criteria, sensitivity, specificity, PPV and NPV and diagnostic accuracy can be increased. This can be used as fair replacement for the echocardiography where echo is not possible. Combination of any two, three or even four criteria will not improve the diagnostic value of the electrocardiography but the combination of Sokolow Lyon and Romhilt Estes point score system will definitely improve the diagnostic efficacy of the ECG for the detection of left ventricular hypertrophy.

LIMITATION

In this study only interventricular septal thickness was used as a diagnostic for LVH on Echo instead of left ventricular mass which could have led to underestimation of prevalence of LVH on Echo. The present authors included all the patients of LVH based solely on ECG criteria, so there were no patients who were positive on Echo and negative on ECG hence overall sensitivity of the ECG could not be assessed. Being a rural tertiary centre, most of the patient present here at late stages of disease because of which the incidence of LVH could be higher in the study as compared to other similar studies conducted at urban areas.

CONCLUSION

Combination or either one of the Sokolow Lyon and Romhilt Estes point score system for ECG diagnosis of LVH has a very high sensitivity. Absence of either any of these criteria can be very well used to rule out the diagnosis LVH in resource limited setting like in the present study. However, because of low specificity of combination or either of these two criteria, present of LVH by either of these two criteria on ECG should be confirmed by Echo.

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