CORRELATION BETWEEN ELECTROCARDIOGRAM AND ECHOCARDIOGRAPHY IN THE ASSESSMENT OF LEFT VENTRICULAR HYPERTROPHY AMONG HYPERTENSION PATIENTS

S. Arunkumar[1], V. Sakthivel[2], K. Kishan Raj[3]

[1]Assistant Professor, Department of Medicine, Vinayaka Mission's Medical College, Karaikal.
[2]Professor and HOD, Department of Medicine, Vinayaka Mission's Medical College, Karaikal.
[3]Postgraduate Student, Department of Medicine, Vinayaka Mission's Medical College, Karaikal.

ABSTRACT

BACKGROUND

In routine clinical practice, the electrocardiogram (ECG) is usually the first method used for diagnosing LVH using various criteria. These ECG criteria generally had shown high specificities and low sensitivity in diagnosing LVH. However, their low sensitivities do not mean that it excludes the presence of LVH.

The aim of this study was to assess the validity of ECG by comparing it with echocardiogram in diagnosing LVH among hypertension patients.

MATERIALS AND METHODS

A prospective longitudinal study was conducted at our hospital for a period of six months among 100 patients with hypertension. The study was started after getting the clearance from the institutional ethical committee. Twelve lead electrocardiography was done with GE electrocardiogram machine. Twelve leads electrocardiography was recorded at the paper speed of 25 mm/second and calibration of 10mm was taken as a standard electrocardiogram. Electrocardiographic criteria used to diagnose left ventricular hypertrophy were Romhilt – Estes Point Score and Sokolow and Lyon Voltage Criteria and total QRS voltage criteria. Later, on all these patients, M-mode echocardiography was performed using Esoate Mylab Five machine. Person performing Echo was blinded to electrocardiographic findings.

RESULTS

The validity of the various ECG criteria in diagnosing LVH in comparison with echocardiogram shows that all the validity parameters like sensitivity, specificity, positive predictive value, negative predictive value and accuracy was found to be high for total QRS criteria than that of Sokolow-Lyon and Romhilt Estes criteria and the difference was also found to be statistically significant. The correlation r value was found to be equal to or less than 0.5 for Sokolow-Lyon and Romhilt Estes criteria, whereas for total QRS the R value was greater than 0.6 but for none of the criteria the P value was found to be statistically significant.

CONCLUSION

Echocardiography is definitely a better tool in the detection of left ventricular hypertrophy. However, improved criteria like total QRS voltage can still be adopted for the detection of LVH at a primary healthcare level.

KEYWORDS

Electrocardiogram, Echocardiography, Left Ventricular Hypertrophy, Hypertension.

HOW TO CITE THIS ARTICLE: Arunkumar S, Sakthivel V, Raj KK. Correlation between electrocardiogram and echocardiography in the assessment of left ventricular hypertrophy among hypertension patients. J. Evid. Based Med. Healthc. 2018; 5(16), 1385-1389. DOI: 10.18410/jebmh/2018/288

BACKGROUND

Literatures had shown that left ventricular hypertrophy to be an extremely strong predictor of cardiovascular morbidity and mortality in whichever method it was diagnosed either by electrocardiogram or by echocardiogram.[1,2] Both echocardiographic left ventricular mass and electrocardiographic measures of cardiac hypertrophy are related to cardiovascular risk both in qualitative as well as quantitative manner.[3,4] The echocardiogram being a gold standard tool in detecting left ventricular hypertrophy, but its cost and operational considerations tend to limit its utility in large-scale population studies and clinical trials.[5,6]

Classically, left ventricular hypertrophy represents an increase in LV mass which in fact related to the pressure or volume overload of left ventricle. In the short run, increase in LV mass may be beneficial by allowing the heart to compensate for increased wall stress and potential hemodynamic compromise but the long-term effect of left ventricular hypertrophy is usually harmful.[7]

Hypertension has long been implicated as the single most important underlying cause for LV hypertrophy. Other risk factors which are considered in the development of LV

Financial or Other, Competing Interest: None.
Submission 05-04-2018, Peer Review 09-04-2018,
Acceptance 11-04-2018, Published 13-04-2018.
Corresponding Author:
Dr. S. Arunkumar,
Assistant Professor,
No. 239, Church Street,
Karaikal – 609602, Pondicherry.
E-mail: varun.kkl@gmail.com
DOI: 10.18410/jebmh/2018/288

hypertrophy include obesity, age, dietary sodium intake, volume load, diabetes, arterial hypertrophy and stiffening, insulin resistance, and the neurohumoral factors like adrenergic factors and renin-angiotensin system.[8]

Previous studies had shown that there are substantial technical problems in securing echocardiographic data among normal population, particularly in the elderly. In contrast, the electrocardiogram is widely available, inexpensive and it is less operator dependent if careful attention is paid to consistent placement of electrodes, and electrocardiographic data are easily obtainable in nearly all patients and participants in epidemiological studies.[9]

In the routine clinical practice, the electrocardiogram (ECG) is usually the first method used for diagnosing LVH for which many validated criteria are available like Sokolow–Lyon,[10] Cornell voltage,[11] Cornell voltage QRS duration product criteria,[12] the Gubner index,[13] and the Romhilt-Estes score.[14,15] These ECG criteria generally had shown high specificities and low sensitivity in diagnosing LVH. However, their low sensitivities do not mean that it excludes the presence of LVH. Cardiac magnetic resonance imaging and three-dimensional echo are recommended for clinical trials investigating LVM regression because of its good accuracy and reproducibility.[16] Today LVH itself found to be an independent risk factor for most of the cardiac diseases and its diagnosis at a primary care level found to be of utmost important and ECG is the only tool available at that level and only very few studies done in India had validated the effectiveness of ECG in diagnosing LVH in comparison with ECHO and so the present study was undertaken.

Aims and Objectives

To assess the validity of ECG by comparing it with echocardiogram in diagnosing LVH among hypertension patients.

MATERIALS AND METHODS

A prospective longitudinal study was conducted at our hospital for a period of six months among 100 patients with hypertension. The study was started after getting the clearance from the institutional ethical committee. All known hypertensive patients with blood pressure more than 140/90 mm hg who are on treatment based on JNC VII criteria were included for the study. Patients with complete bundle branch block, evidence of myocardial infarction, Wolf Parkinson White Syndrome, atrial fibrillation, patients with regional wall motion abnormality, ventricular aneurysm, severe right ventricular volume overload, hypertrophic cardiomyopathy, aortic stenosis which were diagnosed by ECHO were excluded from the study. Socio-demographic history and a detailed clinical examination was conducted on all patients after obtaining the informed consent.

Twelve lead electrocardiography was done with GE electrocardiogram machine. Twelve leads electrocardiography was recorded at the paper speed of 25mm/second and calibration of 10mm was taken as a standard electrocardiogram. Electrocardiographic criteria used to diagnose left ventricular hypertrophy were Romhilt – Estes Point Score and Sokolow and Lyon Voltage Criteria and total QRS voltage criteria.

Later on, all these patients M- mode echocardiography was performed using Esoate Mylab Five machine. Person performing ECHO was blinded to electrocardiographic findings. Patients were studied supine or in left lateral decubitus position with transducer placement in the 3rd to 5th intercostal space. Measurement obtained by way of standards recommended by the American Society of Echocardiography.[17] The following measurements were taken using echocardiogram Left Ventricular Posterior Wall Thickness in diastole (LVPWTd), Inter Ventricular Septal Thickness in diastole (IVSTd), Left Ventricular Internal Dimension in the diastole (LVIDd) and finally the Left Ventricular Mass (LVM) was calculated using Devereux formula.[18] $LVM=1.04\ (LVIDd + IVSTd + LVPWTd)^3 - (LVIDd)^3 - 13.6$ gms. Because left ventricular mass varies directly with the body surface Area, it was commonly indexed for this measure of body size. This was left ventricular mass index (LVMI) expressed in gram/ meter square. LVMI (gram/m2) = LVM/BSA. The upper limit of normal left ventricular mass index for male was defined as 116.07 gm/m2 and for female as 104.36 gm/m2 which is taken as a standard in this study.[19]

All data were entered and analysed using SPSS version 21. Mean, SD and 95% CI was derived for all the parametric variables and the validity of ECG was tested by using sensitivity, specificity, positive predictive value, negative predictive value, percentage of false positives and false negatives.

RESULTS

Table 1 shows the demographic characteristics of the study subjects. It is seen from the table that the mean age of both males and females was almost similar with a overall mean age of 56 years. The mean BMI of the study subjects was 25.98 with proves that majority of the study subjects were more than the normal BMI, only 16% of the entire subjects had normal BMI and 32% were obese with grade I and 15% with grade II obesity. The mean systolic and diastolic BP of the subjects were 153 and 94 mm hg which shows that majority of the subjects were in grade I hypertension according to JNC VII criteria. The various echocardiogram findings such as the thickness of the interventricular septum during diastole, left ventricular internal dimension in diastole, posterior wall thickness of left ventricle in diastole, left ventricular mass and the left ventricular mass index was found to be similar among both the males and females except for the LVM and LVMI which is higher among males than the females (table 2). The validity of the various ECG criteria in diagnosing LVH in comparison with echocardiogram shows that all the validity parameters like sensitivity, specificity, positive predictive value, negative predictive value and accuracy was found to be high for total QRS criteria than that of Sokolow-Lyon and Romhilt Estes criteria and the difference was also found to statistically significant (table 3). The validity of the various ECG criteria like Sokolw-Lyon voltage criteria, Romhilt Estes criteria and

the total QRS criteria in diagnosing LVH based on the socio-demographic characteristics had shown only for the factor BMI<25 the odds ratio was found to be more than 1 for all the three criteria in diagnosing LVH whereas for all the other factors like male gender, female gender and the BMI>25 the odds was less than 1 (Table 4, 5, 6).

The correlation between various ECG criteria and the echocardiogram parameter left ventricular mass and left ventricular mass index was analysed by using Pearson's correlation (R value). R value ranges between -1 to +1. The r value was found to equal or less than 0.5 for Sokolow-Lyon and Romhilt Estes criteria whereas for total QRS the r value was greater than 0.6 but for none of the criteria the p value was found to be statistically significant (table 7).

Variable	Male (n=64) Mean ± SD	Female (n=36) Mean ± SD	Total (n=100) Mean ± SD
Age	56.28 ± 10.3	54.59 ± 11.23	56.01 ± 9.18
BMI	25.75 ± 4.89	27.08 ± 3.72	25.98 ± 5.01
Systolic BP	154.78 ± 18.91	149.79 ± 21.28	153.42 ± 19.71
Diastolic BP	96.81 ± 11.31	93.45 ± 9.91	94.98 ± 10.09

Table 1. Demographic Characteristics and the Blood Pressure of the Study Subjects

Parameter	Male (n=64) Mean ± SD	Female (n=36) Mean ± SD	Total (n=100) Mean ± SD
IVS d (cms)	1.17 ± 0.12	1.08 ± 0.08	1.13 ± 0.07
LVID d (cms)	4.52 ± 0.82	4.56 ± 0.85	4.54 ± 0.80
LVPWT d (cms)	1.16 ± 0.21	1.07 ± 0.30	1.12 ± 0.18
LVM (gm)	235.23 ± 72.25	210.52 ± 81.25	223 ± 78.65
LVMI (gm/m^2)	138.70 ± 40.2	131.58 ± 38.65	133.45 ± 42.31

Table 2. Mean and SD of the Echocardiogram Parameters among the Study Subjects

ECG Criteria	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
Sokolow – Lyon	40	80	52	82	36
Romhilt Estes	46	80	56	85	40
Total QRS	60	93	60	95	50
P value	0.023	0.041	0.671	0.042	0.052

Table 3. Validity of ECG Criteria in Diagnosing LVH in Comparison with Echocardiogram

p value derived by applying Man-Whitney U test

Socio-Demographic Determinant	Sensitivity	Specificity	PPV	NPV	Odds ratio	95% CI	P value
Male	45	86	79	41	0.76	0.65 – 0.84	0.381
Female	35	77	83	35	0.68	0.58 – 0.76	0.615
BMI<25	48	87	85	48	2.819	1.75 – 4.29	0.087
BMI>25	28	62	61	29	0.213	0.17 – 0.312	0.317

Table 4. Validity of Sokolow-Lyon Voltage Criteria in Diagnosing LVH Based on the Various Socio-Demographic Variables

Socio-Demographic Determinant	Sensitivity	Specificity	PPV	NPV	Odds ratio	95% CI	P value
Male	52	82	83	43	0.72	0.65 – 0.86	0.411
Female	41	79	80	34	0.60	0.46 – 0.79	0.585
BMI<25	54	91	88	48	3.51	2.75 – 4.31	0.067
BMI>25	34	60	63	26	0.25	0.16 – 0.32	0.416

Table 5. Validity of Romhilt Estes Criteria in Diagnosing LVH Based on the Various Socio-Demographic Variables

Socio-Demographic Determinant	Sensitivity	Specificity	PPV	NPV	Odds ratio	95% CI	P value
Male	64	95	97	54	1.01	0.85 – 1.28	0.781
Female	56	88	92	46	0.88	0.68 – 1.17	0.665
BMI<25	68	96	94	58	4.28	3.18 – 5.67	0.042
BMI>25	50	72	88	42	0.48	0.28 – 0.64	0.712

Table 6. Validity of Total QRS Criteria in Diagnosing LVH Based on the Various Socio-Demographic Variables

ECG criteria	Pearson's correlation (r value) ECHO Variables		P value
	LVM (gm) (r value)	LVMI (gm/m^2) (r value)	
Sokolow – Lyon	0.312	0.478	0.719
Romhilt Estes	0.425	0.561	0.658
Total QRS	0.689	0.819	0.071

Table 7. Pearson's Correlation between Echocardiogram and Electrocardiogram

DISCUSSION

The Romhilt- Estes Point Scoring System, which when first devised for diagnosing left ventricular hypertrophy, had originally reported a sensitivity of 60% and a specificity of 95%, whereas our study had shown a sensitivity of 40% and 80% specificity. The specificity and the sensitivity were found to be comparatively lower in the present study which is probably due to the determinants of left ventricular hypertrophy like age, sex, grading of blood pressure, duration of hypertension and use of antihypertensive drugs which were not taken into consideration. Similar studies done on R-E scoring system like a study done by Kansal S et al[20] showed a sensitivity of 57% and specificity of 81%, another study done by Reichek and Devereux showed a sensitivity of 50% and a specificity of 95% and in the study done by Denarie etal the R – E system showed a sensitivity of 20 and specificity of 75%.[21] Our study data confirms that Romhilt - Estes Point Score System is specific but not sensitive in diagnosing LVH.

Sokolow-Lyon in their original study claimed that the sensitivity of their Voltage Criteria was 32% and specificity 100%. Our study showed an almost similar sensitivity (40%) but specificity (80%) was lower in our study. It may be due to the body mass index which is less in Asian countries compared to Western countries. Our study data on Sokolow-Lyon Voltage Criteria supports the widespread impression that it is more sensitive and less specific than Romhilt -Estes Point Score System. Echocardiographically detected left ventricular hypertrophy has been found to be 93% sensitivity and 95% specificity in previous studies by using Devereux formula.

In this study, it was showed that sensitivity, specificity and accuracy obtained using echocardiographic criteria for diagnosis of left ventricular hypertrophy when compared with anatomic left ventricular mass; clearly show that this method is highly reliable. Nixon has also confirmed the reliability of this method angiographically.[22] Okin PM found that electrocardiographic criteria for left ventricular hypertrophy has lower sensitivity in women when compared to men even when the gender differences like left ventricular mass, height and weight were taken into account.[23] In our study also a similar trend was observed with Sokolow–Lyon voltage criteria but not with the Romhilt-Estes Point Scoring system. However, it was statistically not significant.

Lauer MS showed that Body mass index more than 30 kg/m2 has been found to be associated with increased prevalence of left ventricular hypertrophy by echocardiography.[24] In our study the sensitivity for the detection of left ventricular hypertrophy in over weight (BMI 26-30 mg/m2) was 28% by Sokolow-Lyon Voltage criteria and 34% by Romhilt – Estes point scoring system, the corresponding figure in obese more than 30 kg/m2 patient were 18% by Sokolow-Lyon Voltage criteria and 17% by Romhilt – Estes point scoring system. Obesity attenuates precordial voltage and reduces sensitivity of electrocardiography.

Use of total 12 lead QRS Electrocardiographic voltage as a criterion for left ventricular hypertrophy has been of recent interest. Roberts et al 1992 studied 57 patients by using 175 mm voltage as the upper limit of normal. They showed that this criterion has a sensitivity of 72% and a specificity of 90%[25] which has highest of any criteria used and similarly our study had also shown the highest sensitivity of 60% and the specificity of 90% for detecting LVH using QRS criteria. Our study had also shown that there was no statistical significant correlation between the echocardiogram and the carious ECG criteria for diagnosing LVH.

CONCLUSION

Echocardiography is definitely a better tool in the detection of left ventricular hypertrophy. This study also confirms the fact that electrocardiography, because of its low sensitivity is considered as a poor screening test. But because of its high specificity in addition, various determinants of left ventricular hypertrophy may also independently influence the detection of left ventricular hypertrophy by electrocardiography. However improved criteria like total QRS voltage can still be adopted for the detection of LVH at a primary healthcare level.

REFERENCES

[1] Kannel WB, Dannenberg AL, Levy D. Population implications of electrocardiographic left ventricular hypertrophy. Am J Cardiol 1987;60(17):85I-93I.

[2] Levy D, Garrison RJ, Savage DD, et al. Prognostic implications of echocardiographically determined left ventricular mass in the Framingham Heart Study. N Engl J Med 1990;322(22):1561-1566.

[3] Schillaci G, Verdecchia P, Porcellati C, et al. Continuous relation between left ventricular mass and cardiovascular risk in essential hypertension. Hypertension 2000;35(2):580-586.

[4] Prineas RJ, Rautaharju PM, Grandits G, et al. Independent risk for cardiovascular disease predicted by modified continuous score electrocardiographic criteria for 6-year incidence and regression of left ventricular hypertrophy among clinically disease free men: 16-year follow-up for the multiple risk factor intervention trial. J Electrocardiol 2001;34(2):91-101.

[5] Kannel WB, Cobb J. Left ventricular hypertrophy and mortality--results from the Framingham study. Cardiology 1992;81(4-5):291-298.

[6] Reichek N, Devereux RB. Left ventricular hypertrophy: relationship of anatomic, echocardiographic and electrocardiographic findings. Circulation 1981;63(6):1391-1398.

[7] Gardin JM, Lauer MS. Left ventricular hypertrophy: the next treatable, silent killer? JAMA 2004;292(19):2396-2398.

[8] Sundstrom J, Lind L, Arnlov J. Echocardiographic and electrographic diagnosis of left ventricular hypertrophy predict mortality independently of each

other in a population of elderly men. Circulation 2001;103(19):2346-2351.
[9] Rautaharju PM, Park L, Rautaharju FS. Standardized procedure for locating and documenting ECG chest electrode positions: consideration of the effect of breast tissue on ECG amplitudes in women. J Electrocardiol 1997;31(1):17-29.
[10] Sokolow M, Lyon TP. The ventricular complex in left ventricular hypertrophy as obtained by unipolar precordial and limb leads. Am Heart J 1949;37(2):161-186.
[11] Casale PN, Devereux RB, Kligfield P, et al. Electrocardiographic detection of left ventricular hypertrophy: development and prospective validation of improved criteria. J Am Coll Cardiol 1985;6(3):572-580.
[12] Norman JE, Levy D. Adjustment of ECG left ventricular hypertrophy criteria for body mass index and age improves classification accuracy: the effects of hypertension and obesity. J Electrocardiol 1996;29 Suppl:241-247.
[13] Gubner R, Ungerleider HE. Electrocardiographic criteria of left ventricular hypertrophy. Arch Intern Med 1943;72(2):196-206.
[14] Romhilt DW, Estes EH. A point-score system for the ECG diagnosis of left ventricular hypertrophy. Am Heart J 1968;75(6):752-758.
[15] Pewsner D, Juni P, Egger M, et al. Accuracy of electrocardiography in diagnosis of left ventricular hypertrophy in arterial hypertension: systematic review. BMJ 2007;335(7622):711.
[16] Alfakih K, Reid S, Hall A, et al. The assessment of left ventricular hypertrophy in hypertension. J Hypertens 2006;24(7):1223-1230.
[17] Feiganbaum H, Armstrong WF, Ryan T. Feiganbaum's echocardiography. Philadelphia USA: Lippincott Williams and Wilkins 1994:658-660.
[18] Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man: anatomic validation of the method. Circulation 1977;55(4):613-618.
[19] Gupta OP, Trivedi SK, Jain AP. Left ventricular muscle mass by echocardiography: methodology. J Assoc Physicians India 1992;40(3):179-180.
[20] Kansal S, Roitman DI, Sheffield LT. A quantitative relationship of electrocardiographic criteria of left ventricular hypertrophy with echocardiographic left ventricular mass: a multivariate approach. Clin Cardiol 1983;6(9):456-463.
[21] Denarié N, Linhart A, Levenson J, et al. Utility of electrocardiogram for predicting increased left ventricular mass in asymptomatic men at risk for cardiovascular disease. American Journal of Hypertension 1998;11(7):861-865.
[22] Nixon JV, Anderson RJ, Cohen ML. Alteration in left ventricular mass and performance in patients treated effectively for thyrotoxicosis. A comparative echocardiographic study. Am J Med 1979;67(2):268-276.
[23] Okin PM, Roman MJ, Devereux RB, et al. Gender differences and electrocardiogram in left ventricular hypertrophy. Hypertension 1995;25(2):242-249.
[24] Lauer MS, Anderson KM, Levy D. Separate and joint influences of obesity and mild hypertension on left ventricular mass and geometry: the Framingham Heart Study. J Am Coll Cardiol 1992;19(1):130-134.
[25] Roberts WC, Odom H, Davis JL, et al. QRS voltage measurements in autopsied men free of cardiopulmonary disease: a basis for evaluating total QRS voltage as an index of left ventricular hypertrophy. Am J Cardiol 1986;58(9):801-804.