Original Article

Sokolow-Lyon Voltage and Cornell Voltage Criteria in the Diagnosis of Left Ventricular Hypertrophy in Obese Individuals

Samata Padaki, Amrut Dambal[1]

Department of Physiology, Gadag Institute of Medical Sciences, Gadag, Karnataka, [1]Department of Biochemistry, Mallareddy Institute of Medical Sciences, Hyderabad, Telangana, India

Abstract

Background and Aim: Left ventricular hypertrophy (LVH) marks the ongoing disease process involving the heart. A precise diagnostic tool needs to be established to accurately determine LVH by electrocardiography (ECG), which itself is a predictor of future cardiovascular mortality and morbidity. Assessment of LVH electrocardiographically by Sokolow-Lyon voltage criteria and Cornell voltage criteria in obese individuals. **Methods:** Obese 50 individuals with LVH secondary to hypertension confirmed by echocardiogram were considered as study subjects. Standard 12-lead ECG was obtained and analyzed for Sokolow-Lyon voltage criteria and Cornell voltage criteria. Statistical analysis was done by unpaired *t*-test using SPSS package version 20. **Results:** According to Sokolow-Lyon voltage criteria, 42 cases (38.27 ± 2.96) and 41 controls (37.23 ± 2.01) had LVH which was statistically nonsignificant. According to Cornell voltage criteria, 36 male cases (35.42 ± 2.98) and 36 controls (32.3 ± 2.13) had LVH and it was statistically significant ($P < 0.000\ 1$). Ten female cases (26.87 ± 2.01) and 7 controls (22.9 ± 2.36) also had LVH and it was statistically significant ($P < 0.002$). About 84% of cases were assessed to have LVH by Sokolow-Lyon voltage criteria whereas 92% of cases were assessed to have LVH by Cornell voltage criteria. **Conclusion:** QRS duration is an independent ECG predictor of the presence of LVH. The Cornell voltage criteria significantly improve identification of LVH relative to Sokolow-Lyon voltage criteria in obese individuals.

Keywords: Cornell voltage criteria, echocardiography, electrocardiography, left ventricular hypertrophy, obesity, Sokolow-Lyon voltage criteria

Received: 01st June, 2017; ***Revised:*** 14th September, 2017; ***Accepted:*** 19th September, 2017

Introduction

Left ventricular hypertrophy (LVH) refers to the thickening of the myocardium of the left ventricle of the heart. It is a natural reaction to aerobic exercise and strength training but is considered pathological secondary to the high blood pressure (BP) and cardiovascular diseases. LVH itself is not a disease but can be considered as a marker for the diseases involving the heart, in the form of either an increase in the afterload as in long-standing mitral insufficiency, aortic stenosis, aortic insufficiency, hypertension or any primary disease of the myocardium like hypertrophic cardiomyopathies.[1]

The diagnosis of LVH should be made preferably using echocardiography, with which the thickness of the muscle of the heart can be measured, that correlates with its actual mass. Normal thickness of the left ventricular myocardium is from 0.6 to 1.1 cm as measured at the very end of the diastole. If the myocardium is >1.1 cm thick, the diagnosis of LVH can be made.[2] However, economic considerations and technical difficulties restrict the large-scale use of echocardiography for this purpose. Hence, standard 12-lead electrocardiography (ECG) remains the most simple and widely used initial screening test for the noninvasive detection of LVH in clinical practice, epidemiological studies, and clinical trials. The principal ECG changes associated with ventricular hypertrophy are increases in QRS amplitude and duration, changes in instantaneous and mean QRS vectors, abnormalities in the ST segment and T waves, and abnormalities in the

Access this article online

Quick Response Code:

Website: www.ijcep.org

DOI: 10.4103/ijcep.ijcep_29_17

Address for correspondence: Dr. Samata Padaki, Department of Physiology, Gadag Institute of Medical Sciences, Gadag - 582 101, Karnataka, India.
E-mail: drsamatapadaki@gmail.com

How to cite this article: Padaki S, Dambal A. Sokolow-Lyon voltage and Cornell voltage criteria in the diagnosis of left ventricular hypertrophy in obese individuals. Int J Clin Exp Physiol 2017;4:129-32.

P wave. These changes have been correlated with direct or indirect assessments of ventricular size or mass to establish electrocardiographic criteria for the diagnosis of hypertrophy. However, electrocardiographic criteria based only on QRS voltage have exhibited poor sensitivity for LVH whereas high levels of specificity are necessary for adequate clinical utility.[3-9]

Many studies have been conducted to improve electrocardiographic criteria for the identification of this condition in patients with different cardiovascular diseases. The major criterion for the identification of LVH is the increased QRS-complex voltage. Although none of them is perfect, by using multiple criteria sets, the sensitivity and specificity can be increased.

Obesity is known to be associated with an increased anatomical LVH, usually an increased left ventricular mass estimated by echocardiography.[10] Left ventricular mass is most commonly indexed to body surface area or height while defining LVH.[2] A study by de Simone G *et al*.[11] suggests that normalization for height to 2.7 power (height$^{2.7}$) decreases variability and reduces the impact of obesity on the determination of hypertrophy and may improve the prediction of adverse prognosis. In a study of patients with mild or moderate hypertension, the Cornell voltage-duration product was more often in the LVH range in obese patients than in the nonobese, whereas the Sokolow-Lyon criteria was less often in the LVH range in obese patients.[12]

Several reports suggest the superiority of Cornell criteria over the classic Sokolow-Lyon criteria. However, many studies have established cutoff points to separate individuals with normal left ventricular mass from those with LVH in the North American population. However, the simple extrapolation of these criteria to other populations can lead to a significant error since the QRS voltage depends not only on the cardiac mass but also on the anthropometric data, on fat deposition in the upper body and on the breast size in women. Thus, we undertook this study to assess the LVH by Sokolow-Lyon voltage criteria and Cornell voltage criteria in obese individuals.

Materials and Methods

The present comparative study was conducted in the Department of Physiology, S. Nijalingappa Medical College and Hanagal Sri Kumareshwar Hospital and Research Centre. Fifty obese patients of either sex in the age group of 25–70 years with body mass index (BMI) ≥30 kg/m^2 were considered as cases and fifty nonobese patients in the age group of 25–70 years with BMI between 20 and 25 kg/m^2 were considered as controls. Both the groups were recently diagnosed by the cardiologist to be suffering from LVH secondary to hypertension confirmed by echocardiogram. Ethical clearance was obtained from the Institutional Ethical Committee. Written informed consent was taken in the form of signature on the informed consent form.

History taking included all present, past, and recent illnesses of the individual. Individuals with complete bundle branch block, previous myocardial infarction, Wolff-Parkinson-White syndrome, atrial fibrillation, and use of digitalis were excluded from the study. They were explained about the purpose and the procedure of the study. Individuals were taken into confidence to relieve their apprehension. Standard 12-lead ECG was obtained (Philips Company Page Writer 300 pi) after 10 min of rest. The machine was calibrated before recording ECG with paper speed at 25 mm/s and amplitude of stylus deflection at 1 mV/cm. The ECG tracing was decoded, and for the analysis, a magnifying lens that allowed a magnification of × 5 of the tracing was used to obtain higher precision in the analysis. The QRS complex axis and duration, the R wave amplitude in leads aVL, V5, and V6, the S-wave amplitude in V1, V2 and V3, were quantified and analyzed for Sokolow Lyon voltage criteria and Cornell voltage criteria. Sokolow-Lyon voltage criteria: SV1 or V2+ RV5 or V6 ≥35 mm.[13] Cornell voltage criteria: RaVL + SV3 ≥20 mm for women and ≥28 mm for men.[4]

Data were expressed in terms of mean ± standard deviation (SD). Statistical analysis was done by unpaired *t*-test using SPSS package version 20 (IBM).

Results

The results are expressed as mean ± SD. $P < 0.01$ was considered as statistically significant. The mean age and the distribution of cases and controls with respect to gender, BMI, systolic and diastolic BP and heart rate are shown in Table 1 and they are statistically nonsignificant.

According to Sokolow-Lyon voltage criteria, 42 cases (38.27 ± 2.96) and 41 controls (37.23 ± 2.01) had LVH and 8 cases (29.32 ± 2.76) and 9 controls (30.75 ± 1.78) had no LVH. This was statistically nonsignificant, $P = 0.06$ and 0.21, respectively [Table 2]. According to Cornell voltage criteria, 36 male cases (35.42 ± 2.98) and 36 controls (32.3 ± 2.13) had LVH, and it was statistically significant ($P < 0.000\,1$). Likewise, 10 female cases (26.87 ± 2.01) and 7 controls (22.9 ± 2.36) also had LVH, and it was statistically significant ($P < 0.002$).

Percentage of study individuals was taken according to which 84% of cases were assessed to have LVH by Sokolow-Lyon voltage criteria whereas 92% of cases were assessed to have

Table 1: Characteristics of the Subjects

Characteristics	Cases		Controls	
	Males (*n*=38)	Females (*n*=12)	Males (*n*=41)	Females (*n*=9)
Age (years)	51.3±10.5	51.7±10.2	50.41±9.2	52.13±10.24
BMI (Kg/m^2)	33.6±3.5	34.4±3.2	23.34±1.2	24.1±0.7
Systolic BP (mm Hg)	162.8±18.5	168.5±19.4	158.2±5.2	155.0±13.3
Diastolic BP (mm Hg)	98.6±7.5	96.4±5.6	95.7±4.3	98.2±3.2
Heart Rate (beats/min)	94.5±13.2	92.3±12.4	89.3±7.8	91.1±9.7

LVH by Cornell voltage criteria. Similarly, 82% of controls were assessed to have LVH by Sokolow-Lyon voltage criteria whereas 86% of controls were assessed to have LVH by Cornell voltage criteria [Tables 3, 4 and Figure 1].

Discussion

The diagnosis of LVH should preferably be made using echocardiography. Only a small part of obese individuals with echocardiographic LVH may be detected by ECG at high levels of specificity.[14] The evolution of these new methods provides a compelling reason to reassess the role of the ECG in detecting cardiac hypertrophy and related abnormalities and to update our practice on the basis of new research findings and technological developments.

Table 2: Sokolow Lyon Voltage Criteria in the study subjects

	Group	Mean±S.D	*N*	*P*
≥ 35 mm	Cases	38.27±2.96	42	0.06
	Controls	37.23±2.01	41	
< 35 mm	Cases	29.32±2.76	8	0.21
	Controls	30.75±1.78	9	

P < 0.01 (Significant)

Table 3: Cornell Voltage Criteria in the study subjects

	Group	Mean±S.D	*N*	*P*
Male ≥28 mm	Cases	35.42±2.98	36	<0.0001**
	Controls	32.3±2.13	36	
Female ≥20 mm	Cases	26.87±2.01	10	0.002*
	Controls	22.9±2.36	7	
Male <28 mm	Cases	24.03±3.56	2	0.73
	Controls	23.12±2.96	5	
Female <20 mm	Cases	17.52±1.65	2	0.59
	Controls	18.6±1.78	2	

*Statistically significant, **Extremely significant

Table 4: Percentage of Subjects with LVH

LVH Criteria	Groups	% of subjects with LVH
Sokolow Lyon Voltage Criteria	Cases	84%
	Controls	82%
Cornell Voltage Criteria	Cases	92%
	Controls	86%

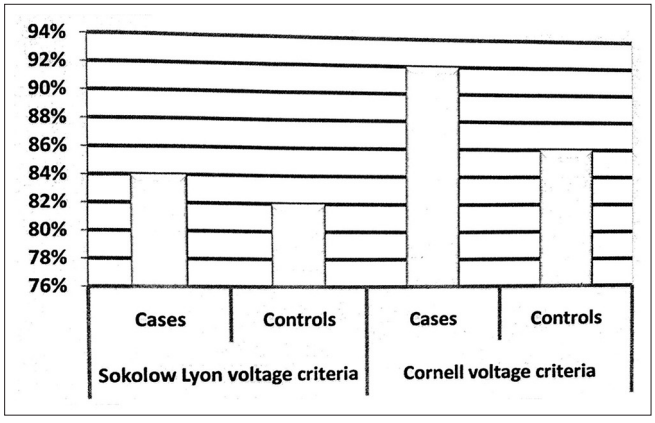

Figure 1: Percentage of individuals with left ventricular hypertrophy

In our study, we found the better performance of the Cornell voltage criteria as compared to Sokolow-Lyon voltage criteria which is explained by the analysis of vectorcardiographic changes induced by LVH. With the increased ventricular mass, the electric forces become oriented both horizontally (corresponding to the R wave in aVL) and posteriorly (S wave in V3). In addition, the V3 lead is closer to the left ventricle and is probably less influenced by variations in the distance between the myocardium and the leads.[15]

The differences in the magnitude of the QRS complex regarding gender are partly attributed to a lower myocardial volume in females and also to the longer distance between the cardiac mass and the precordial leads, because of the breast tissue.[5]

The sensitivity of ECG criteria for the identification of LVH in the presence or absence of obesity according to the different methods of indexing left ventricular mass was not done in our study. Independent of the definition of hypertrophy, Cornell voltage adjusted for age and BMI demonstrated significantly higher sensitivities in obese than in nonobese individuals. Although Sokolow-Lyon criteria has a high specificity, its ability to reliably detect anatomical echocardiographic LVH compared with other ECG criteria has been shown to be relatively low, especially among obese individuals.

Limitations of the study

The major limitation of the study is the less sample size, especially in female group that might have contributed to the statistical output of the results.

Conclusion

Cornell voltage criteria had 92% and 86% of diagnostic utility for LVH and hence could be considered to be better ECG diagnostic criteria for LVH in peripheral sectors where echocardiographic facilities are unavailable. The evolution of new criteria provides a compelling reason to reassess the role of ECG in detecting cardiac hypertrophy and related abnormalities and to update our practice on the basis of new research findings and technological developments.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Meijs MF, Bots ML, Vonken EJ, Cramer MJ, Melman PG, Velthuis BK, *et al.* Rationale and design of the SMART heart study: A prediction model for left ventricular hypertrophy in hypertension. Neth Heart J 2007;15:295-8.

2. 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.
3. Casale PN, Devereux RB, Kligfield P, Eisenberg RR, Miller DH, Chaudhary BS, *et al.* Electrocardiographic detection of left ventricular hypertrophy: Development and prospective validation of improved criteria. J Am Coll Cardiol 1985;6:572-80.
4. Casale PN, Devereux RB, Alonso DR, Campo E, Kligfield P. Improved sex-specific criteria of left ventricular hypertrophy for clinical and computer interpretation of electrocardiograms: Validation with autopsy findings. Circulation 1987;75:565-72.
5. Reichek N, Devereux RB. Left ventricular hypertrophy: Relation of anatomic, echocardiographic and electrocardiographic findings. Circulation 1981;63:1391-8.
6. Murphy ML, Thenabadu PN, de Soyza N, Meade J, Doherty JE, Baker BJ, *et al.* Sensitivity of electrocardiographic criteria for left ventricular hypertrophy according to type of cardiac disease. Am J Cardiol 1985;55:545-9.
7. Devereux RB, Casale PN, Eisenberg RR, Miller DH, Kligfield P. 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.
8. Levy D, Labib SB, Anderson KM, Christiansen JC, Kannel WB, Castelli WP, *et al.* Determinants of sensitivity and specificity of electrocardiographic criteria for left ventricular hypertrophy. Circulation 1990;81:815-20.
9. Romhilt DW, Bove KE, Norris RJ, Conyers E, Conradi S, Rowlands DT, *et al.* A critical appraisal of the electrocardiographic criteria for the diagnosis of left ventricular hypertrophy. Circulation 1969;40:185-95.
10. Lauer MS, Anderson KM, Kannel WB, Levy D. The impact of obesity on left ventricular mass and geometry. The Framingham Heart Study. JAMA 1991;266:231-6.
11. de Simone G, Devereux RB, Roman MJ, Alderman MH, Laragh JH. Relation of obesity and gender to left ventricular hypertrophy in normotensive and hypertensive adults. Hypertension 1994;23:600-6.
12. Sokolow M, Lyon TP. The ventricular complex in left ventricular hypertrophy as obtained by unipolar precordial and limb leads. Am Heart J 1949;37:161-86.
13. Noble LM, Humphrey SB, Monaghan GB. Left ventricular hypertrophy in left bundle branch block. J Electrocardiol 1984;17:157-60.
14. Levy D, Castelli WP. Determinants of sensitivity and specificity of electrocardiographic criteria for left ventricular hypertrophy. Circulation 1990;81:815-820.
15. Noble LM, Mongham GB. Left ventricular hypertrophy in left bundle block. J Eletrocardiol. 1984;17:157-160.