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Original article

Assessment of voltage criteria for left ventricular hypertrophy in adult hypertensives in south-western Nigeria

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ABSTRACT

Background: Left ventricular hypertrophy (LVH) is a common pathophysiological consequence of hypertension. Various voltage (ECG) criteria exist for evaluation of LVH. This study assessed the performance of 4 commonly used ECG criteria in south-western Nigeria.

Materials and methods: A cross-sectional descriptive study of adult hypertensive subjects. Participants were assessed for LVH using 4 ECG criteria: Sokolow–Lyon, Araoye code system, Cornell voltage, and Gubner–Ungerleider criteria. Echocardiography was used to determine the left ventricular mass index for the participants, and a value greater than 125 g/m^2 was used as the cut-off point for LVH. The sensitivity, specificity, accuracy, positive and negative predictive values were determined for each of the ECG criteria.

Results: 90 subjects (45 males, 45 females) participated in the study. The prevalence of LVH by echocardiography was 32.2%. The prevalence of LVH by voltage criteria were: 45.6%, 42.2%, 34.4%, 13.3% by Sokolow–Lyon, Araoye code system, Cornell, and Gubner–Ungerleider criteria, respectively. The sensitivity and specificity respectively of the ECG criteria were 58.62% and 60.66% (Sokolow–Lyon), 48.28% and 60.65% (Araoye code system), 51.72% and 73.77% (Cornell), and 13.79% and 86.89% (Gubner–Ungerleider).

Conclusion: Out of the 4 ECG criteria, Araoye code system, Cornell and Sokolow–Lyon criteria compared favorably well with echocardiography and may be used in the initial assessment of LVH in adult hypertensive subjects. However, a combination of any of the 3 criteria with Gubner–Ungerleider criterion will be more clinically useful.

1. Introduction

Left ventricular hypertrophy (LVH) is a progressive structural change involving the left ventricular myocardium. LVH is characterized by increase in the size and workload of the cardiac chambers. LVH, which is assessed by electrocardiogram or echocardiogram, is an independent risk factor for cardiovascular and cerebrovascular events. LVH is also a major factor in the etiopathogenesis of cardiac arrhythmias, ischemic heart disease, congestive heart failure, and sudden cardiac death.[1–4]

LVH is a common a complication of hypertension, the leading non-communicable disease in Nigeria.[5] The prevalence of hypertension varies with the cut-off value used and the population involved. The crude prevalence of hypertension in Nigeria is 11.2%.[5] Therefore, proper assessment of left ventricular hypertrophy in patients with hypertension is not only important but also of therapeutic and prognostic relevance.[6]

Many methods are used to assess LVH though the gold standard is probably the echocardiogram.[7] However, this facility is still largely a specialized one, available only in a few hospitals in Nigeria. A set of criteria based on electrocardiogram (ECG), a more readily available, simple, affordable, easy to use and portable tool has been developed for assessment of LVH. These include; Sokolow–Lyon[8] and Cornell's criteria,[9] Cornell's voltage product,[10] Araoye code system,[11,12] Gubner–Ungerleider criterion,[9] Framingham score,[13] Mcphie[14] and Wilson criteria,[15] Manning and Smiley criterion,[16] Mazzoleni criterion,[17] Perugia score,[18] Minnesota code[19] and Romhilt–Estes Point Score System.[20] In Nigeria, only few studies have evaluated the suitability of the electrocardiographic criteria in the assessment of LVH among adult hypertensive subjects. This study, therefore, compared 4 commonly used voltage criteria with echocardiography to assess their suitability for routine use in the assessment of LVH in adult hypertensive subjects.

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2. Materials and methods

Ninety consecutive adult subjects with established hypertension diagnosed at the cardiac clinic were recruited for the study. There were 45 males and 45 females. The ECGs of the patients were evaluated for the presence of left ventricular hypertrophy using 4 ECG criteria: Sokolow–Lyon (SV1 + RV5 or V6 > 35 mm), Gubner–Ungerleider (SIII + RI > 25 mm), Araoye code system (SV2 + RV6 > 35 mm in women or > 40 mm in men or RI > 12 mm in both sexes), and Cornell's criteria (SV3 + RaVL > 20 mm in women or > 28 mm in men). The subjects were re-evaluated using echocardiography. Sonoline G60S Ultrasound system with 4.2 MHz transducers was used for cardiac scanning. Two Dimensional (2D)-guided M-mode measurements were made according to American Society of Echocardiography (ASE) convention.[21] The linear dimensions of septal wall, left ventricular cavity, and posterior wall along the left ventricular minor axis, identified as the largest diameter perpendicular to the septum and posterior wall, were measured at the end of diastole (at onset of R wave). The measurements were recorded in centimeters. The estimation of left ventricular mass (LVM) was based on the formula derived by Devereux and colleagues.[7]

$$\mathrm{LVM} = 0.8\left(1.04\left[(\mathrm{LVIDd} + \mathrm{PWTd} + \mathrm{IVSTd})^3 - (\mathrm{LVIDd})^3\right]\right) + 0.6\mathrm{g}$$

where LVIDd = left ventricle internal dimension in diastole, PWTd = posterior wall thickness in diastole, IVSTd = interventricular septal thickness in diastole, 1.04 = specific gravity of the myocardium.

The LVM index partition value > 125 g/m^2 for both sexes[22] was utilized for determination of left ventricular hypertrophy and the sensitivity, specificity, accuracy, positive predictive value and negative predictive value of each of the voltage criteria were estimated. The Ethics and Research Committee of Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife approved the study. The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 15.0 software. Continuous variables were expressed as mean ± standard deviation (SD). Categorical variables were expressed as percentages. Comparison of means was done by Student *t* test. 95% confidence interval was used to determine significance of probability, and *P* value of <0.05 was taken as statistically significant.

3. Results

Ninety (90) hypertensive subjects (45 males, 45 females) participated in the study. 75.6% of the study population was above 50 years of age. The mean age was 57 ± 12 years. The most frequent age-group was 50–59 years. The mean height for males and females were 1.71 ± 0.08 m and 1.60 ± 0.07 m, respectively. The mean weight ± SD for male and female were 75.41 ± 15.45 kg and 69.73 ± 16.59 kg, respectively. The mean body mass index ± SD was 27.38 ± 6.46 kg/m^2 in females and 25.94 ± 5.34 kg/m^2 males (Tables 1 and 2).

Table 1
Demographic characteristics.

Variable	Range	Mean ± SD	Mode	Median
Age (years)	30–87	57.17 ± 12.07	57.00	56.50
Height (m)	1.50–1.97	1.65 ± 0.09	1.55	1.65
Weight (kg)	41–115	72.57 ± 16.19	55.00	71.50
BMI (kg/m^2)	15.6–43.4	26.66 ± 5.94	16.95	26.2
SBP (mmHg)	90–220	141.74 ± 13.05	140	140
DBP (mmHg)	50–130	87.00 ± 13.05	90	90
BSA (m^2)	1.04–2.96	1.79 ± 0.25	1.61	1.79

DBP = diastolic blood pressure, SBP = systolic blood pressure, BSA = body surface area, BMI = body mass index.

Table 2
Demographic characteristics according to gender.

Variable	Male (*N* = 45)	Female (*N* = 45)	*P* value
	Mean ± SD	Mean ± SD	
Age (years)	57.44 ± 11.84	56.89 ± 12.41	0.829
Height (m)	1.71 ± 0.08	1.60 ± 0.07	< 0.001*
Weight (kg)	75.41 ± 15.45	69.73 ± 16.59	0.096
BMI (kg/m^2)	25.94 ± 5.34	27.38 ± 6.46	0.251
BSA (m^2)	1.85 ± 0.19	1.74 ± 0.29	0.041**
SBP (mmHg)	141.40 ± 18.39	140.67 ± 18.76	0.852
DBP (mmHg)	90.44 ± 11.27	85.33 ± 9.44	0.022**

BSA = body surface area, BMI = body mass index, SD = standard deviation, DBP = diastolic blood pressure, SBP = systolic blood pressure, *P value < 0.001, **P value < 0.05.

The prevalence of LVH by echocardiography was 32.2%. The prevalence of LVH by voltage criteria were: 45.6%, 42.2%, 34.4%, 13.3% by Sokolow–Lyon, Araoye code system, Cornell, and Gubner–Ungerleider criteria, respectively. Table 3 showed the comparison among the voltage criteria using echocardiography as the gold standard. The sensitivity and specificity respectively of the ECG criteria were 58.62% and 60.66% (Sokolow–Lyon), 48.28% and 60.65% (Araoye code system), 51.72% and 73.77% (Cornell), and 13.79% and 86.89% (Gubner–Ungerleider). The accuracies, positive, and negative predictive values of each of the ECG criteria were shown in Table 4.

4. Discussion

This study evaluated 4 ECG criteria for LVH using echocardiography as the gold standard. In all, 90 (45 males, 45 females) hypertensive subjects were assessed in this study, of which about a third (32.2%) had echocardiographic evidence of LVH. Our study was consistent with that of Verdecchia et al[23] which reported the prevalence of LVH of 27.2% using the same LVMI cut-off value (125 g/m^2) for males and females. The prevalence of LVH in hypertension varies with the echocardiographic cut-off value used. Dada et al[21] in a study of 100 hypertensive subjects, obtained a prevalence of 34% at LVMI of 126 g/m and 130 g/m for females and males, respectively, while Katibi[24,25] reported a prevalence of 35% among 60 hypertensive subjects studied. Adebiyi,[26] in the study of 457 hypertensive Nigerians, obtained a prevalence range of 30.9%–56.0% using various partition values for LVMI. The lowest prevalence was obtained when LVM was indexed for body surface area (BSA) using a partition value of 125 g/m^2. The highest prevalence was obtained when LVM was indexed for height raised to power of 2.7 using a partition value of 46.7 g/Ht$^{2.7}$ and 49.2 g/Ht$^{2.7}$ for females and males, respectively.

The prevalence of LVH determined by ECG criteria obtained in this study ranged from 13.3% to 45.6%. The prevalence obtained by

Table 3
Comparisons among ECG criteria using echocardiography as the gold standard.

Criteria	TP	TN	FP	FN
SLC	17 (18.9%)	37 (41.1%)	24 (26.7%)	12 (13.3%)
ACS	14 (15.6%)	37 (41.1%)	24 (26.7%)	15 (16.7%)
CC	15 (16.7%)	45 (50.0%)	16 (17.8%)	14 (15.6%)
GUC	4 (4.4%)	53 (58.9%)	8 (8.9%)	25 (27.8%)

ACS = Araoye code system, CC = Cornell criterion, SLC = Sokolow–Lyon criterion, GUC = Gubner–Ungerleider criterion, TP = True positive, TN = True negative, FP = False positive, FN = False negative.

Table 4
Performance of four ECG criteria.

ECG criteria	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
ACS	48.28	60.65	56.67	36.84	71.15
CC	51.72	73.77	66.67	48.39	76.27
SLC	58.62	60.66	60.00	41.46	75.51
GUC	13.79	86.89	63.33	33.33	67.94

PPV = positive predictive value, NPV = negative predictive value, ACS = Araoye code system, CC = Cornell criterion, SLC = Sokolow–Lyon criterion, GUC = Gubner–Ungerleider criterion.

Sokolow–Lyon criteria was the highest (45.6%), and the value obtained by Gubner–Ungerleider criterion was the lowest (13.3%). The prevalence of LVH by Araoye code system, Sokolow–Lyon, and Cornell criteria were higher than that obtained by echocardiography. Falsely high prevalence of LVH obtained by the ECG criteria likely occurred because of the presence of false positives in the LVH cases identified by the various criteria. However, the prevalence of LVH obtained by Gubner–Ungerleider criterion (13.3%) was too low when compared with that obtained by echocardiography because of the low sensitivity of the criterion. This finding was consistent with the report from a study by Verdecchia et al.[23] Dada et al[21] reported a higher prevalence of LVH using the Araoye code system and Sokolow–Lyon criteria than that obtained by echocardiography while the prevalence of LVH obtained by Cornell's criteria and Romhilt–Estes score were lower than that obtained by echocardiography.

This present study revealed that ECG has low sensitivity and high specificity as a diagnostic tool for left ventricular hypertrophy among adult hypertensive subjects. The low sensitivity of various ECG criteria is a challenging issue, which limits the diagnostic value of electrocardiogram in the assessment of LVH.[21,27] Despite this, LVH diagnosed by ECG is clinically important because of its prognostic and therapeutic values.[1]

Dada et al[21] demonstrated that the Araoye code system had higher sensitivity and lower specificity when compared with Sokolow–Lyon and Cornell criteria. However, in this present study, Araoye code system, Cornell voltage, and Sokolow–Lyon criteria compared favorably well with echocardiography. The 3 ECG criteria (Araoye code system, Cornell voltage, and Sokolow–Lyon criteria) had good combined performance indices and were more sensitive than Gubner–Ungerleider criterion.

5. Conclusion

Out of the 4 ECG criteria, Araoye code system, Cornell, and Sokolow–Lyon criteria compared favorably well with echocardiography and may be used in the initial assessment of LVH in adult hypertensive subjects. However, a combination of any of the 3 criteria with Gubner–Ungerleider criterion will be more clinically useful.

Conflicts of interest

All authors have none to declare.

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