

Correlation of Electrocardiogram with Echocardiographic left ventricular mass in adult Nigerians with systemic hypertension

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Summary

Systemic hypertension, High Blood Pressure (HBP) is common in Nigeria with up to 10 to 15% prevalence among adults. HBP is readily complicated by left ventricular hypertrophy (LVH), recognised to herald a series of adverse outcomes in cardiovascular health. In order to devise a method of assessment of LVH that is objective, readily available, affordable and easily operable in the face of soaring cost of the more recent techniques, correlation of electrocardiographic (ECG) LVH parameters was done with echocardiographic (ECHO) left ventricular mass (LVM). ECG is objective, affordable and easily operable, while ECHO is highly accurate for measurement of LVM. One hundred and fifty-five hypertensives were studied (123m; 32f). A statistically significant correlation was found with a maximum coefficient of 0.36 in males only. ECG can thus offer an objective alternative for assessment of LVH in HBP in males where ECHO is not available or practicable.

Keywords: *Electrocardiography, Echocardiography, Hypertension, Left Ventricular Mass*

Résumé

Hypertension est plutôt courant au Nigeria avec un taux de fréquences de 10 à 15% permis les adultes. Hypertension se complique facilement par hypertrophie ventriculaire de gauche qui présente une série des résultats négatifs de la santé cardiovasculaire. Pour concevoir une méthode d'évaluation objective, très disponible, abordable et très opérative face aux prix des techniques récentes galopantes, une corrélation d'électrocardiographie a été faite avec échocardiographie masse ventriculaire de gauche. Electrocardiographie est objective, abordable est très opérable tandis qu'échocardiographie reste très fidèle dans l'évaluation de masse ventriculaire de gauche. Cent cinquante victimes d'hypertension ont été observés- 123 hommes, 32 femmes. Une corrélation statistiquement significative a été obtenue avec un coefficient de 0.36 permis les hommes seulement. L'électrocardiographie ainsi peut présenter un alternatif objectif dans l'évaluation de masse ventriculaire de gauche dans les cas d'hypertension permis les hommes où l'échocardiographie n'est pas disponible ni praticable.

Introduction

LVH is an important and consistent complication of HBP.^{1,2} It is thought that this occurs as a result of increased afterload imposed on the heart in HBP, which forces a structural and functional adaptation. The latter results in LVH involving an increase in muscle mass achieved by hypertrophy of the myocytes, accompanied by high degrees of polyploidy^{3,4} as well as hyperplasia of cardiac connective tissue cells.^{5,6} In addition, functional adaptation involves increase in heart rate, minute volume and initially contractility.⁷ With persistence of HBP and maintenance of LVH, functional adaptation decompensates and unless effective therapy is interjected, left ventricular failure ensues as the major cardiac haemodynamic consequence.⁸⁻¹⁰

Prior to the development of cardiac failure however, LVH has been shown to be associated with a greater risk of complications in patients with any given level of blood pressure than in those without LVH. ECG LVH is associated with increased risk of cardiovascular disease morbidity and mortality.¹¹⁻¹³ ECG LVH is associ-

ated with reduced cardiac output and greater prevalence of post exertional myocardial ischaemia manifested by ST segment depression in patients with HBP.¹⁴ Recently, ECHO LVH has also been shown to carry a poor prognosis.^{15,16}

Since LVH is such a deleterious factor in cardiovascular disease, an inexpensive and effective method of detecting it early would have great clinical value. Current methods of diagnosis include physical examination, ECG, radiography and ECHO.

Physical examination cannot identify early LVH as many features found on clinical examination reflect cardiac damage.¹⁷ Chest X-ray reveals LV enlargement by a combination of increased cardiothoracic (CT) ratio and increased convexity of the lateral cardiac shadow. The correlation between CT ratio and blood pressure is however very poor.¹⁸

Electrocardiography, though said to be poorly sensitive by some authorities, is specific.^{19,20} It has remained an important investigation in hypertensive patients as it is quick, relatively cheap, readily available, easy to operate and lends itself to field and epidemiologic studies.^{21,22}

Echocardiography is about the best of the non-invasive techniques in terms of accuracy of measurements, reproducibility of results and absence of complications.²³ ECHO estimates of LVM correlate well with anatomic measurements.²⁴ If therefore, ECG LVH criteria are shown to have significant correlation with ECHO LVM, then ECG can continue to be utilized for effective clinical assessment of LVH due to HBP in the absence of ECHO, especially in poor countries.

Subjects and Methods

One hundred and fifty-five hypertensive subjects (123 males; 32 females) were studied with both ECHO and ECG. This was the final group from 180 subjects initially qualified by blood pressure measurement. Twenty-five subjects were excluded because of the following conditions: rheumatic valvular heart disease (12); non rheumatic valvular heart disease (3); metabolic heart disease (6); genetic asymmetric septal hypertrophy (1); myocardial infarction (1) and complete heart block (2).

HBP was defined as either established systemic arterial blood pressure $\geq 160/95$ mm Hg²⁵ or hypertensive heart failure as defined by Araoye and Olowoyeye.²⁶ Blood pressure was measured in the sitting position with a mercury sphygmomanometer and Korotkoff Phases I and V were taken as systolic and diastolic readings respectively.

Standard 12-lead ECG was done using a 1997 model Dongjiang Electrocardiograph whose technical details conform to international standards.²⁷ The recordings were done at a paper speed of 25 millimetres per second and a voltage calibration of 10 millimetres per millivolt. The subjects lay supine and the electrodes were positioned in accordance with international recommendations.²⁷ The ECG were read by the author and the following were recorded: R wave amplitude in leads, I, II, III, aV_F, aV_L and V₃ to V₆; S wave amplitude in V₁ to V₃; QRS complex frontal plane axis by the hexaxial reference system;²⁸ QRS duration; Intrinsicoid deflection duration; P wave duration; presence of strain pattern (asymmetric T wave inversion); QT interval corrected for heart rate (QTc) by Bazett's formula; Sokolow-Lyon LVH voltage criteria (SV₁ + RV₅ or RV₆ > 35mm);²⁹ Code I of Araoye LVH criteria (SV₂ + RV₆ > 40mm (males); >35mm (females));³⁰ Romhilt - Estes (RE) Point score for LVH;³¹ Cornell Voltage for LVH (SV₃ + RaV_L > 28mm)³² and Wolff Voltage (SV₂ + RV₅ > 35mm).³³ For

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RE Point score, 5 points was taken as LVH.

ECHO was done with a Siemens Sonoline CD Echocardiograph. Two-dimensionally guided M-mode echo was done with patients in the partial decubitus position. The transducer was placed in the 4th left intercostal space near the sternal edge, and if necessary moved laterally and/or to a different interspace so that both mitral valve leaflets could be visualized with the transducer perpendicular to the chest wall. Measurements were made and LVM calculated according to the Penn convention.²⁴ LVM values were divided by corresponding values of body surface area (BSA) and height in metres (Ht) to obtain values of LVM index (LVMI).

ECHO LVM and LVMI were correlated with the above listed ECG criteria of LVH using SPSS Statistics Software. In addition, ECG and ECHO data were subjected to stepwise linear regression analysis using STATISTICA software.

Males and females were treated separately.

Results

Baseline characteristics of study participants are detailed in Table 1. Statistically significant positive correlation between ECG LVH criteria

Table 1 Baseline characteristics of study participants

Baseline Variables	Males			Females		
	NBP N=105	IIBP N=123	p value	NBP N=63	IIBP N=32	p value
Age (yrs)	40.8±30.2	55.5±21.2	<0.01(S)	43.3±30.2	53.0±17.6	<0.03(s)
Height (cm)	171.5± 12.8	169.9± 12.2	> 0.05(ns)	163.3 ± 11.4	158.8 ± 7.6	<0.01(s)
Weight(kg)	70.5 ± 22.6	72.0 ± 12.6	>0.40(ns)	69.0 ± 28.0	65.7 ± 21.0	>0.24(ns)
BSA (m ²)	1.82±0.30	1.83 ± 0.34	>0.84(ns)	1.75±0.24	1.67 ± 0.24	<0.03(s)

s-Statistically significant ns- Not statistically significant NBP- Normotensive IIBP-Hypertensive

Table 2 Correlation coefficients of ECG parameters versus ECHO LVM and LVMI in males

		RE	SV ₁ + RV ₅	SV ₁ + RV ₆	SV ₂ + RV ₅	SV ₂ + RV ₆	SV ₃ + RaV _L
LVM	C.C.	0.3024	0.1583	0.2658	0.2573	0.3424	0.2852
	P	0.001x	0.080	0.003x	0.004x	0.000x	0.001x
LVMI	C. C.	0.3339	0.1597	0.2681	0.2692	0.3555	0.3018
	P	0.000x	0.078	0.003x	0.003x	0.000x	0.001x
BSA	C.C.	0.3081	0.1493	0.2575	0.2535	0.3400	0.2885
	P	0.001x	0.099	0.004x	0.005x	0.003x	0.001x

LVM Left ventricular mass
BSA Body surface area
Ht Height
C. C. Correlation coefficient
P 2 tailed significance
x Significant P value

Table 3 Correlation coefficients of ECG parameter versus ECHO LVM and LVMI in Females

		RE	SV ₁ + RV ₅	SV ₁ + RV ₆	SV ₂ + RV ₅	SV ₂ + RV ₆	SV ₃ + RaV _L
LVM	C.C.	0.1740	-0.0774	-0.0644	-0.1011	-0.0921	-0.0098
	P	0.341	0.674	0.726	0.582	0.616	0.962
LVMI	C. C.	0.2562	0.0657	0.0629	0.0341	0.0252	0.0186
	P	0.157	0.721	0.732	0.853	0.819	0.920
BSA	C. C.	0.1771	-0.0423	-0.0258	-0.0720	-0.0612	0.0063
	P	0.332	0.818	0.889	0.695	0.739	0.973

Note: No significant P value

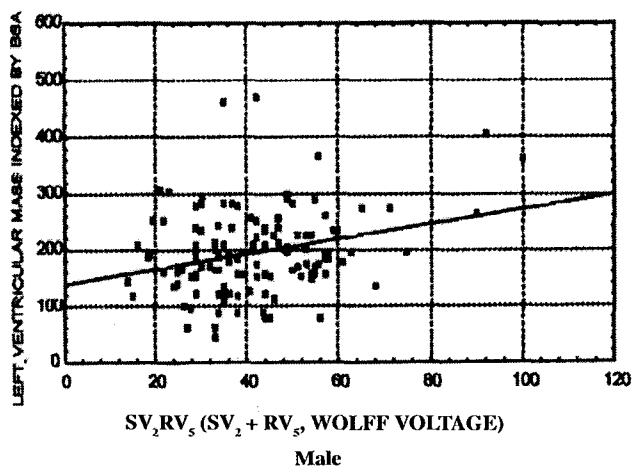


Fig. 1 Left ventricular mass indexed by body surface area against Wolff voltage

$$y = 138.599 + 1.332x + eps$$

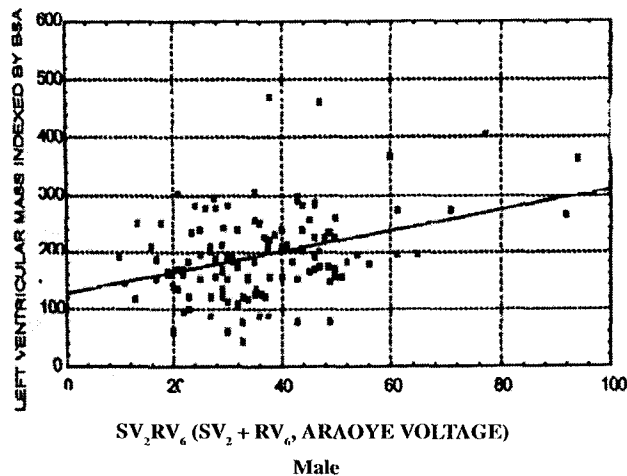


Fig. 2 Left ventricular mass indexed by body surface area against Araoye voltage

$$y = 126.91 + 1.834x + eps$$

and echo LVM and LVMI was demonstrated in males only. (Table 2). The coefficients of correlation were however low, the highest being 0.36. There was no significant correlation in females (Table 3).

Linear regression in males shows moderate scatter and some outliers (Figures 1 and 2).

Discussion

The result from this study shows that in males there is a posi-

tive, statistically significant correlation between ECG LVH criteria in HBP and the corresponding ECHO measurements. This agrees with the findings of a previous study on the subject.²³ In females in this study, no significant correlation was demonstrated. The low number of females that participated in the study may have affected the results.

The existence of significant positive correlations between ECG and ECHO measurements in males and the derivation of linear regression equations that mathematically express the relationships

prove that indeed a quantitative relationship exists between ECG LVH criteria as used in this study and ECHO LVM and LVMI. Precious studies showed no statistically significant correlation between ECHO LV posterior wall thickness and ECG QRS voltages.^{34,35} Although Bahler et al³⁵ found statistically significant correlation between ECG LVH criteria and ECHO interventricular septal thickness (IVST) at end diastole, McFarland et al³⁶ stated that the primary echocardiographic correlate of left ventricular hypertrophy was not an increase in wall thickness, but rather an increase of estimated (calculated) left ventricular mass. They concluded therefore, that left ventricular mass estimated from an echocardiogram was a better indicator of left ventricular hypertrophy than echocardiographic measurements of left ventricular posterior wall thickness and interventricular septal thickness. A later study by Devereux et al³⁷ further concluded that sex-specific ECHO LVMI criteria gave the best separation between patients with normal versus increased necropsy LVM.

The above findings imply that certain ECG criteria of LVH can continue to be utilized with a measure of confidence, in the clinical assessment of LVH in poor countries. ECG assessment of LVH will likely be most useful in serial observations.

It is to be noted that only Code I of the three Araoye LVH Criteria was used in this study for convenience, and must necessarily have attenuated the overall sensitivity and specificity of the Criteria.

The correlation coefficients for males in this study are low, ranging from 0.25 to 0.36 and agree with the findings of Crow et al.²³ This figure reinforces the knowledge that there are difficulties inherent in the use of ECG in the study of LVH.^{2, 20,38,39} Errors deriving from dipole location, torso shape, different lead strengths, age, weight, gender and smoking habits are some of the factors that contribute to these difficulties. In addition is the fact that as Carter and Estes⁴⁰ observed, some of our conventional criteria generally derived from groups of patients who are considered to have 'pure' LVH on clinical grounds, may not reflect left ventricular thickness alone. They went on to conclude that their finding of a correlation between QRS amplitude and other ECG parameters on one hand, and only those hearts with weights above accepted limits of normal rather than all hearts on the other hand, suggested that muscle mass was not the parameter to which amplitude was primarily related; some other factor associated with heart disease might be more important.

In conclusion, the findings of this study support the continued use of certain ECG criteria for the evaluation of LVH due to HBP in males. In females, further and larger studies are required to determine the usefulness of the ECG for the evaluation of LVH resulting from HBP.

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