# PERFORMANCE OF THE PEGUERO-LO PRESTI CRITERIA FOR THE DIAGNOSIS OF LEFT VENTRICULAR HYPERTROPHY IN PATIENTS WITH CARDIAC DISEASE IN IBADAN, NIGERIA.

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## ABSTRACT

***Background:*** **Many criteria have been developed to predict left ventricular hypertrophy using an electrocardiogram (ECG). However, one major common limitation of all has been their low sensitivity. Recently, a novel criterion has been proposed, which is believed to have higher sensitivity without a compromise in specificity.**

***Objective:*** **Therefore, in our study, we aimed to test this novel ECG criterion prospectively in large, unselected cardiac patients in Ibadan, Nigeria.**

***Methods:*** **Patients who were referred to our echocardiography laboratory due to various aetiologies were prospectively enrolled. The novel Peguero-Lo Presti criterion was assessed along with other established ECG criteria. The left ventricular mass index was calculated using echocardiography. The performance of each index was evaluated.**

***Results:*** **Overall, 336 patients were included in the final analysis. The mean age was 57.94±14.98 and 178 (53.0%) of them were males. The sensitivity and specificity of the Peguero-Lo Presti criterion were 59% and 66%, respectively. Although the highest sensitivity belonged to the Peguero-Lo Presti criterion, in ROC analysis, it showed modest predictive capability, which was similar to the established Cornell voltage criterion.**

***Conclusion:*** **Although this novel criterion had higher sensitivity, the overall performance was similar to the current indices.**
**Further adjustments, particularly based on age and body mass index, may yield better results.**

**Keywords:** Left ventricular hypertension, Electrocardiography, Peguero-Lo presti criterion, Cornell voltage criterion.

## INTRODUCTION

Left ventricular hypertrophy (LVH) is a well-established predictor of incident cardiovascular event.[1,2] It is associated with increased morbidity and mortality.[1,2] The establishment of the diagnosis of LVH is often by echocardiography, although cardiac magnetic resonance imaging (MRI) is the gold standard.[3, 4] In clinical practice, 12-lead ECG is usually employed in the assessment of LVH. This is because 12-lead is cheap, readily available, and cost-effective. At the moment there are over thirty ECG criteria for LVH.[5,6] Many of these have limited sensitives and specificities. Thus, the search for better 12-lead ECG criteria for the diagnosis of LVH is still being investigated. Currently, the Sokolow-Lyon[7] and Cornell criteria[8] are most commonly used for the diagnosis of LVH in the medical literature. In many studies, the latter performs better than the former.[9] However, though the Cornell criteria have a specificity as high as 90%, its sensitivity is poor (20-40%).[10]

It is, therefore, necessary to explore a criterion whose sensitivity and specificity are good.

Not long ago, Peguero *et al.*[11] published a criterion with improved sensitivity and specificity. The criterion is measured by the addition of the maximum S-wave in any lead and the S-wave in lead V4 (SV4) This is believed to improve sensitivity without effects on the specificity. The criterion has been tested in a few populations and scarcely in native Africans.[12]

Therefore, this study aims to test the sensitivity and specificity of this novel criterion in the Nigerian

population and compare it with the Cornell and Sokolow-Lyon criteria.

## MATERIAL AND METHODS

This was a cross-sectional study conducted at the Cardiology Unit of the Department of Medicine, University College Hospital, Ibadan, Nigeria. It was conducted between June 1 and July 31, 2021, and all the patients presenting for 12-lead ECG were recruited for the study. They also had their echocardiography done as well.

Those who were younger than eighteen years, who were pregnant, had cancer or mental illness were excluded from the study. In addition, we excluded non-consenting patients, those who had bundle branch blocks, poor echo window, poor 12-lead ECG quality, and paced ECG rhythm from the study.

### 12-Lead ECG Analysis

A 12-lead resting ECG was performed for each subject. The 12-lead ECGs were performed following international standards. All the ECGs were recorded in the supine position. For each recording, the stylus control was set at 10mm/mV (except in very high voltages when it was set at 5mm/mV). Its paper speed was adjusted to 25mm/sec.

A Contec 800G 12-lead ECG machine (Contec Medical Systems Co., Ltd Qinhuangdao, Hebei Province, People's Republic of China) was used for ECG recording. The validity value of this machine is typically around 95%. (https://www.gimaitaly.com/DocumentiGIMA/Manuali/EN/M33316EN.pdf) We measured the tallest R and R' and the deepest S or QS waves in each lead. The Sokolow- Lyon voltage criteria were computed by adding the amplitude of the S-wave in lead V1 and the amplitude of the R-wave in V5 or V6. A cut-off value of 3.5mV or 35mm was used for the diagnosis of LVH.[7]

For the Cornell voltage criteria, the sum of the amplitude of R-wave in lead aVL and the S or QS complex in lead V3 (RaVL + SV3) A cut-off value of >2.8mV/ 28mm in males and >2.0mV 0r 20mm in females.[8]

The Peguero-Lo Presti criterion represent the sum of the amplitude of the deepest S wave in any lead with the S wave in lead $V_4$ ($S_D$+$SV_4$).[11]

### Echocardiography

Echocardiography was performed on the subjects in the left lateral decubitus position according to the recommendations of the American College of Echocardiography (ASE).[13] Two-dimensional guided measurements of the left ventricular dimensions were made according to the ASE guideline.[14-16] Measurements obtained included the left ventricular (LV) diameter in end-diastole (LVIDd), LV diameter in end-systole (LVIDs), interventricular septal thickness in diastole (IVSTd), and LV posterior wall thickness in diastole (PWTd) Measurements were averaged over 3 cardiac cycles.[14] One cardiologist performed all the echocardiography. In our laboratory, the intra-observer concordance correlation coefficient ranged from 0.76 to 0.98 while that of the inter-observer concordance ranged from 0.82 to 0.96

### Calculation of derived variables

Left ventricular mass (LVM) was calculated by the equation of Devereux and Reichek[17]: LV mass (in grams) = $0.8\{1.04[([LVEDD + IVSd + PWd]^3 LVEDD^3)]\} + 0.6$. This has been shown to yield LVM closely related to autopsy measurements ($r=0.90$)[18] and has good interobserver reproducibility ($\tilde{n}=0.93$) in one study.[19] Left ventricular mass index (LVMI) was calculated by dividing the value of LVM/Height**2.7 (to the power of 2.7).[20] LVH was defined by LV mass indexed by allometric signal ($Height^{2.7}$) >$51g/m^{2.7}$.[21] This partition value of $51g/ht^{2.7}$ was used since this was the only criterion that demonstrated as the optimal threshold value for left ventricular hypertrophy in Blacks irrespective of gender in two previous studies.[22,23]

### Ethical consideration

The study was approved by the University of Ibadan and University College Hospital Research Ethics Committee (UI/EC/19/0371) on 06/09/2019 as part of the Ibadan heart failure project and was conducted according to international ethical standards of research on human subjects as enshrined by the Declaration of Helsinki

### Statistical analysis

SPSS version 11.0 software (SPSS, Chicago, IL, USA) was used in the analysis of the data. Continuous variables were expressed as mean ± SD while categorical variables were expressed as counts (percentages). The normality of continuous variables was assessed using the Kolmogorov- Smirnov statistics. Comparison between two groups was assessed by the student's t-test for independent variables while the LVM/Height**2.7 (to the power of 2.7) $\chi^2$ analysis was used to compare proportions.

The sensitivity and specificity of the three ECG criteria were calculated using echocardiographically derived LVH as the standard. The receiver operating curves (ROC) were computed for the different criteria. Furthermore, a pair-wise comparison was carried out

for the different ECG criteria by the use of the differences between the area under the curve.

A 2-tailed p-value of 0.05 was assumed statistically significant.

## RESULT

### Baseline characteristics

Three hundred and sixty-one subjects were recruited during the period. Twenty-five participants were excluded because of poor echo window (eight), bundle branch block (ten), paced ECG (two), and poor-quality ECG (five).

The data of the remaining three and thirty-six (336) were analysed. There were 178 males and 158 females (53% and 47% respectively) About 70.4% were aged 50 years and above. The age distribution is as shown in table 1. The mean age of the study population was 59.5 (15.0). They were aged between 20 and 91 years.

About 86.9% of the subjects were aged 40 years and above. The mean body mass index was 26.2kg/m2 and about 20% were obese. In terms of clinical diagnoses, hypertensive heart disease, rheumatic heart disease, and idiopathic dilated cardiomyopathy were the common diagnoses as shown in Table 1. Table 2 shows the echocardiographic variables.

### Sensitivity and specificity of the three criteria for LVH

The sensitivity of Cornell, Sokolow-Lyon, and Peguero-lo Presti criteria were 0.41 (95% CI 0.35-0.48), 0.36(95%CI 0.30-0.42), and 0.59(95%CI 0.52-0.65). The corresponding specificity were 0.82(95%CI, 0.74-0.89), 0.78 (95%CI, 0.68-0.85) and 0.66 (95%CI, 0.57-0.75) respectively. In addition, the positive predictive

**Table 1.** Characteristics of the study subjects

| Characteristics/Variables | N=336 |
|---|---|
| **Sex** | |
| Male | 178(53%) |
| Female | 158(47%) |
| **Mean age(years) (mean (SD)** | |
| All | 59.5(15.0) |
| Male | 59.7(14.4) |
| Female | 56.0(15.5) |
| **Age range (years)** | |
| All | 20-91 |
| Male | 25-91 |
| Female | 20-87 |
| **Age group (years)(n/%)** | |
| 20-29 | 10(3) |
| 30-39 | 34(10.1) |
| 40-49 | 55(16.4) |
| 50-59 | 78(23.2) |
| 60-69 | 73(21.7) |
| ≥70 | 86(25.6) |
| Body weight (kg) | 71.4(16.0) |
| Height (cm) | 165.0(8.5) |
| Body mass index(kg/sqm) | 26.2(5.6) |
| **Body weight class** | |
| Underweight | 15(4.5) |
| Normal weight | 151(44.9) |
| Overweight | 100(29.9) |
| Obese | 70(20.8) |
| Body surface area | 1.78(0.204) |
| **Clinical diagnosis** | |
| Hypertension/Hypertensive heart disease | 250(74.4) |
| Rheumatic Heart disease | 26(7.7) |
| Dilated Cardiomyopathy | 23(6.8) |
| Ischaemic heart disease | 8(2.4) |
| Pericardial disease | 6(1.8) |
| Peripartum Cardiomyopathy | 6(1.8) |
| Corpulmonale | 5(1.5) |
| Thyroid heart disease | 5(1.5) |
| Apparently normal subject | 7(2.1) |

**Table 2.** Echocardiographic variables

| Variable | Mean (SD) |
|---|---|
| Interventricular septal thickness (diastole)(cm) | 1.27(0.39) |
| Interventricular septal thickness (systole)(cm) | 1.52(0.91) |
| Left ventricular Internal dimension (diastole)(cm) | 5.30(1.17) |
| Left ventricular Internal dimension (systole)(cm) | 3.98(1.36) |
| Left ventricular posterior wall thickness(diastole)(cm) | 1.17(0.31) |
| Left ventricular posterior wall thickness (systole)(cm) | 1.53(0.38) |
| Left ventricular mass (gram) | 271.3(123.7) |
| | 245.6(144.8) |
| Indexed Left ventricular mass ($g/cm^{2.7}$) | 70.4(32.0) |
| | 63.8(37.9) |

*Values are mean and standard deviation*

value (PPV), negative predictive value, and accuracy are stated in table 3.

The values of these parameters for any traditional ECG criteria and all three ECG criteria tested are shown in table 3.

The novel criterion has the best sensitivity and accuracy while the Cornell criteria have the best specificity.

**The receiver operating curve (ROC) of the three ECG criteria**

Analysis of the predictive performance of these criteria by the ROC shows that the value of AUC was 0.66,

**Table 3.** ECG Criteria

| ECG criteria for LVH | Sensitivity | Specificity | PPV | NPV | Accuracy | Cohen's Kappa | McNemar Test |
|---|---|---|---|---|---|---|---|
| Cornell | 0.41 [0.35 - 0.48] | 0.82 [0.74 - 0.89] | 0.83 [0.75 - 0.90] | 0.39 [0.33 - 0.46] | 0.54 [0.49 - 0.60] | 0.181 | <0.001 |
| Sokolow-Lyon | 0.36 [0.30 - 0.42] | 0.78 [0.68 - 0.85] | 0.77 [0.68 - 0.85] | 0.36 [0.30 - 0.43] | 0.49 [0.44 - 0.55] | 0.102 | <0.001 |
| Peguero-Lo Presti | 0.59 [0.52 - 0.65] | 0.66 [0.57 - 0.75] | 0.79 [0.72 - 0.85] | 0.43 [0.35 - 0.51] | 0.61 [0.56 - 0.66] | 0.217 | <0.001 |
| Any traditional Criteria | 0.56 [0.50 - 0.63] | 0.62 [0.52 - 0.71] | 0.76 [0.69 - 0.82] | 0.40 [0.32 - 0.48] | 0.58 [0.53 - 0.63] | 0.157 | <0.001 |
| All ECG criteria | 0.69 [0.62 - 0.75] | 0.50 [0.41 - 0.60] | 0.75 [0.68 - 0.80] | 0.43 [0.34 - 0.52] | 0.63 [0.57 - 0.68] | 0.182 | 0.107 |

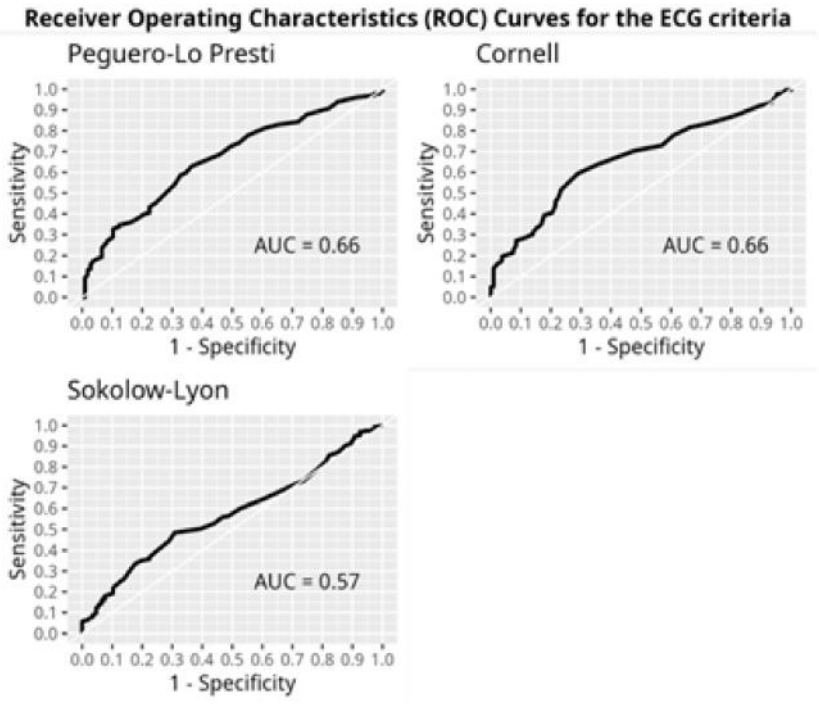


**Figure 1:** Receiver operating characteristics (ROC) Curves for the ECG criteria

0.66, and 0.57 for the Peguero-Lo Presti, Cornell and Sokolow-Lyon criteria respectively as shown in figure 1.

## DISCUSSION

The most popular method for detecting cardiac abnormalities is still the electrocardiogram (ECG), particularly for left ventricular hypertrophy (LVH), which is strongly associated with cardiovascular-related morbidity and mortality.[1, 24] Earlier studies have shown that the commonly used ECG diagnostic criteria are not highly sensitive in identifying LVH.[25]

The most used diagnostic standards for LVH diagnosis are Cornell and Sokolow-Lyon. These criteria have sensitivity values between 20% and 40% and specificities between 90% and 100%.[25] These existing criteria are not as sensitive as the recently described criteria by Peguero *et al.*[11] When compared to the common ECG criteria, the novel Peguero-Lo Presti criterion had the best sensitivity and specificity (62.5% and 87.3%, respectively).[11] It also performed better than previous validated criteria in the diagnosis of LVH in the octogenarian population.[26]

The Peguero-Lo Presti index was based on a new cardiac electrophysiological concept.[11] Unlike the earlier ECG criteria for the diagnosis of LVH which were based on the measurement of the highest amplitude of the R wave in various leads alone or combined with other components, Peguero and his colleagues suggested that the S wave may be a better reflection of the activation of the myocardial and epicardial left ventricular free wall that occurs after about 50 msec of the left ventricular depolarisation.[11] They opined that changes in left ventricular mass may be better picked by electrophysiological changes represented by the S wave. The authors demonstrated that the S waves of the limb and precordial leads correlated better with increased left ventricular mass as compared to the R waves. In addition, they suggested that because of the variations in the distance between the torsum and the heart, the location of the surface electrode and the body habitus may be responsible for poor electrocardiographic detection and reproducibility of changes in cardiac structure. They, therefore, proposed that the measurement of the highest voltage in any single lead rather than a fixed single lead would improve accuracy.[11] They therefore concluded that this may be the reason their criterion outperformed earlier described criteria.

In this study, we tested the performance of the novel Peguero-Lo Presti ECG criteria alongside Cornell and Sokolow-Lyon criteria in the diagnosis of left ventricular hypertrophy in patients with cardiac diseases. Our result demonstrated that Peguero-Lo Presti had a higher sensitivity of -0.59 than Cornell-0.41 and Sokolow-Lyon-0.36. This is consistent with the finding in the Asian population[27] and that of a systematic review and meta-analysis which reported a higher sensitivity of the Peguero-Lo Presti [0.56, 95% CI 0.51-0.61] than Cornell voltage index [0.36, 95% CI 0.31-0.42] and Sokolow-Lyon criteria [0.24, 95% CI 0.18-0.31].[28] Similar to previous studies[28], Cornell had the best specificity [0.82] and Peguero-Lo Presti[0.66] the least.

On the other hand, in a recent report from Cameroon[12], the Peguero-Lo Presti criteria did not outperform the Sokolow-Lyon or Cornell product.[12] The authors also noted that hypertension and gender influenced the agreement between ECG criteria and echocardiography in the detection of LVH, age and obesity did not.[12] This is similar to the report by Keskin *et al.* in a Turkish population.[30] They reported that the Peguero-Lo Presti criterion had better sensitivity than the Cornell criterion (17.5% vs 9.7%), but poorer specificity (94.5% vs 98.2%) and poorer overall performance based on the AUC (0.64 vs 0.67).

These discrepancies may be explained by several factors. The original description of the Peguero-Lo Presti criteria was retrospective and based on a small sample size. The profile of patients studied by various authors may be contributory. For example, the influence of body habitus as well as body mass index was not accounted for by Peguero and colleagues as well as our study. However, obesity was shown not to have a significant influence on the agreement between ECG criteria and echocardiography in the detection of LVH in the study from Cameroon.[12]

The LV geometric pattern in the study population may also affect the result. Some authors have shown that eccentric LVH is less accurately detected by 12-lead ECG than concentric LVH.[29]

Another factor that may affect the performance is race. Some studies have shown that the performance of the Peguero-Lo Presti criterion may be affected by ethnicity and race.[30]

Nevertheless, our study suggests that the Peguero-Lo Presti criterion has better sensitivity but poorer specificity when compared to Sokolow-Lyon or Cornell criteria.

Our study is not without limitations. This is a hospital-based study. Our findings may not be translated to the general population. The sample size is small and as such a larger sample or multicentre study is advocated. The gold standard for the diagnosis of LVH is cardiac

MRI. This has not been employed in the diagnosis of LVH in this study.

## CONCLUSION

Although the Peguero-Lo Presti criterion had higher sensitivity, the overall performance was similar to the Sokolow-Lyon and Cornell criteria.

Further adjustments, particularly based on age and body mass index and the use of cardiac MRI in the diagnosis of LVH, may yield better results. Finally we are aware of a recent systematic review on the performance of the Peguero-Lo Presti criterion. Almost all the papers cited were from non-African populations. This work has filled that gap.[28]

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