Accuracy criteria voltage electrocardiography left ventricular hypertrophy to distinguish types of left ventricular hypertrophy geometry

O Tumbur[1*], Z Safri[2,3] and R Hassan[2,3]

[1]Tarutung Hospital, North Tapanuli, Indonesia
[2]Faculty of medicine, University of Sumatera Utara, Medan, Indonesia
[3]Adam Malik Hospital, Departement of Internal Medicine, Medan, Indonesia
[*]Corresponding author: octotumbur@gmail.com

Abstract. Different types of left ventricular hypertrophy geometry are associated with different risk of cardiovascular disease. The purpose of this study was to determine the role of various ECG voltages of LVH to distinguish the type of LVH geometry. A cross-sectional study from June to November 2015, 100 patients in Adam Malik Hospital Medan. The result of LVH ECG criteria of Sokolow-Lyon was not met then obtained normal left ventricular geometry with 60% sensitivity, 72.22% specificity, and 71% accuracy. The eccentric type of LVH is obtained when the Cornel Voltage is not met; the sensitivity is 25%, specificity 71.88%, and 55% accuracy. Concentric geometric hypertrophy when the RV6/V5> 1 ratio is satisfied, the sensitivity is 55.56%, specificity 56.36%, and 56% accuracy. The RV6/V5>1 ratio was not met, the concentric geometry type of hypertrophy remodeling was determined with a sensitivity of 55.56%, specificity 49.45%, and 50% accuracy. Conclusions, various LVHECG criteria distinguish the type of LVH geometry. Sokolow-Lyon and Cornel Voltage sensitivity and specificity are better than the RV6/V5 ratio.

1. Introduction

Left ventricular hypertrophy is one of the important risk factors for angina pectoris, myocardial infarction, heart failure, etc. Left ventricular hypertrophy exacerbates the coronary circulation, thus lowering coronary reserves and resulting in myocardial perfusion disorders.[1-3] Left ventricular hypertrophy is an abnormal increase in left ventricular mass caused by an increase in chronic heart workload. The most common cause is increased cardiac pump to increase afterload, as in hypertension and aortic stenosis.[2] In echocardiography, the prevalence of left ventricular hypertrophy in hypertensive patients is more than 50%, while electrocardiographically obtained 15−20%.[3,4-6]

Based on Gerdts et al[3] study known echocardiography can distinguish left ventricular hypertrophy geometry, i.e., concentric remodeling, eccentric LV, or concentric LV. The geometric type of hypertrophy is associated with various risks of cardiovascular diseases, such as concentric remodeling with risk of stroke and cardiovascular mortality, eccentric LV with risk of cardiovascular infarction and cardiovascular mortality, and LV concentrations with only cardiac infarction.[7-9]

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2. Method

The cross-sectional study was conducted in RSUP H. Adam Malik June-November 2015 period approved by Research Ethics Committee of Faculty of Medicine Universitas Sumatera Utara / Adam Malik Hospital of the subject who has signed informed consent.

The study used a large formula of diagnostic test sample (figure 1) with a minimum of 99 samples (value Zα = 1,96; sensitivity value = 20%; d = 10%; 62% prevalence); Men and women >40 years old. All subject performed either electrocardiography or echocardiography. The inclusion criteria were the patients suspected of left ventricular hypertrophy heart disease from ECG criteria. Exclusion criteria were no ECG and complete echocardiography, patients with generalized edema, malignancy, and immunosuppressant use. ECG and Echocardiography performed by one supervisor of acardiologist.

$$N = \frac{Z\alpha^2 \times sen \times (1-sen)}{d^2 \times P}$$
$$= \frac{(1,96)^2 \times 0,20 \times (1-0,20)}{(0,10)^2 \times 0,62}$$
$$= 99 \text{ samples}$$

Figure 1. Large formula of diagnostic test sample.

The ECG criteria for determining left ventricular hypertrophy in this study were voltage criteria: Sokolow-Lyon (SV1 + RV5 cut-off >35 mmV) criteria, Cornell voltage (SV3 + RaVL = female cut-off >22 mmV, male >28 MmV), and Ratio RV6/5 (cut-off> 1). In this study, echocardiography was used to obtain the measurements of LVEDD, IVSd, PWd. Then from those measurements with the help of LV mass calculator, four types of left ventricular hypertrophy geometry, normal geometry, eccentric left ventricular hypertrophy, concentric left ventricular hypertrophy, and concentric left ventricular hypertrophy Remodeling.

Statistical analysis using SPSS v.20 program, with Kolmogorov-Smirnov test to assess the normality of data distribution. Diagnostic Test Table 2x2 assessed the sensitivity and specificity of ECG criteria for left ventricular hypertrophy for geometric types based on echocardiography results. The receiving operating characteristic (ROC) curve test is performed to get the value of under curve area (AUC). Determination of ECG voltage accuracy of left ventricular hypertrophy to differentiate left ventricular hypertrophy geometry type based on Tomita[10] research. Results $p<0.05$ were considered significant.

3. Results

100 subjects were obtained with a median age of 56.5 years (minimum 41 years and maximum 85 years), 47 men (47%) and 53 women (53%), As well as an average BMI of 21.99 kg/m^2 (table 1).

From the electrocardiographic results with the Sokolow-Lyon criteria of a median height of 35 (min 6-max 41) mmV, with the criteria of high median Cornel Cornel 24 (min 8-max 30) mmV, and R ratio V6/V5 median value 0.9 (min 0.4-max 4).

The result of echocardiography in the form of LVEDD was 50.79 ± 9.83 mm, the median value of 12.25 (min 6.6 sd max 29.0) mm, and PWD median value 11 (min 5.2-Max. 20) mm. Through the calculation of echocardiography results obtained LV mass result of median value 221 (min 99-max 774) g, LVMI median value 134.5 (min 57-max 492) g/m^2. Normal results of 10% geometry, concentric remodeling LVH 9%, concentric hypertrophy LVH 45%, and eccentric hypertrophy LVH 36% (figure 2).

Table 1. Basic characteristics of research subjects.

Variable	N (100 patient)	*p*[a]
Age (year)	56.5 (41-85)	**0.004**
Sex		
Male	47 (47%)	
Female	53 (53%)	
Weight (kg)	57.91 ± 7.53	0.106
Height (cm)	162 (151 - 173)	0.004
BMI (kg/m^2)	21.99 ± 1.95	0.137
Sokolow-Lyon criteria (mmV)	35 (6 - 41)	**0.00**
Cornel Voltage criteria (mmV)	24 (8 - 30)	**0.00**
Ratio R V6/V5 criteria	0.9 (0.4 - 4)	**0.00**
Echocardiography value :		
LVEDD (mm)	50.79 ± 9.83	0.200
IVSD (mm)	12.25 (6.6 - 29.0)	0.10
PWD (mm)	11.0 (5.2 - 20)	**0.003**
Echocardiography calculation :		
LV mass (g)	221 (99 - 774)	**0.003**
LVMI (g/m^2)	134.5 (57 - 492)	**0.002**
RWT	0.45 (0.2 - 1.26)	**0.009**
Type of geometry		
Normal geometry (%)	10 (10%)	
Concentric remodeling LVH (%)	9 (9%)	
Concentric hypertrophyLVH(%)	45 (45%)	
Eccentric hypertrophyLVH (%)	36 (36%)	

[a]Kolmogorov-Smirnov test

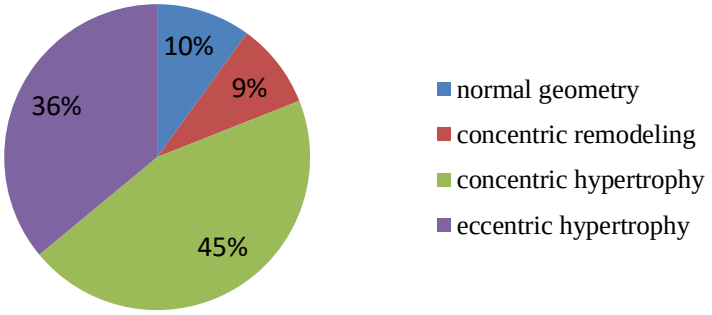

Figure 2. Types of geometry LVH.

A diagnostic test was performed to assess the sensitivity and specificity of ECG criteria in left ventricular hypertrophy using echocardiography. The Sokolow-Lyon sensitivity criteria of 72.22% and specificity of 60.00%, Cornel sensitivity criteria 77.78% and specificity 70.00%, and theRV6/V5 ratio of sensitivity 51.11% and specificity 70.00% (table 2).

The sensitivity test and the specificity of determining the type of left ventricular hypertrophy in the 'flow chart' as in Tomita et al.[10], showed the results as in figure 4.

Table 2. Sensitivity and specificity of ECG criteria on left ventricular hypertrophy.

ECG criteria	Cut-off value	Sensitivity	Specificity	PPR[a]	NPR[b]	PPV[c]	NPV[d]	Accuracy
Sokolow-Lyon	≥ 3.5 (mV)	72.22%	60.00 %	1.81	0.46	94.2%	19.35%	71%
Cornell Voltage	Male > 2.8 (mV) Female > 2.2 (mV)	77.78%	70.00 %	2.59	0.32	95.89%	25.93%	77%
Ratio RV6/V5	>1	51.11%	70.00 %	1.7	0.7	93.88%	13.73%	58.3%

[a] Positive probability ratio
[b]Negative probability ratio
[c] Positive predictor value
[d]Negative predictor value

With ROC test obtained curve according to figure 3.

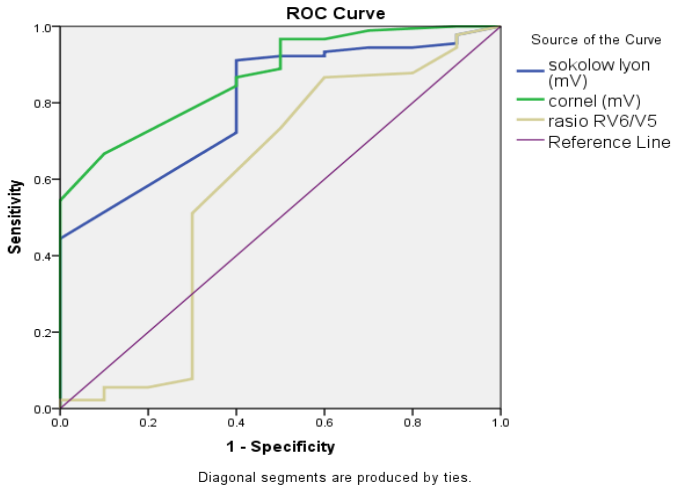

Figure 3. ROC curve of LVH. Sokolow Lyon: AUC = 79.9% (p= 0.002; CI95% 67.3-92.6%), Cornel Voltage: AUC = 86.8% (p = 0,000; CI95% 77.3-96.4%),Ratio RV6 / V5: AUC = 58.3% (p = 0.389; CI95% 35-81.7%).

4. Discussions

A 'flow chart' (diagram) to distinguish the type of left ventricular hypertrophy geometry using the ECG criteria of left ventricular hypertrophy ECG (figure 4). The diagram refers to the research of Tomita et al[10]. Although the results of the sensitivity and specificity are weak, the flowchart distinguishes the left ventricle hypertrophy geometry type practically using ECG criteria.

Overall sensitivity and specificity were weak, but the Sokolow-Lyon and Cornel Voltage criteria were better than the RV6/V5 ratio. This suggests the Sokolow-Lyon and Cornel Voltage criteria are better at determining the normal or abnormal type of normal left ventricular hypertrophy geometry.

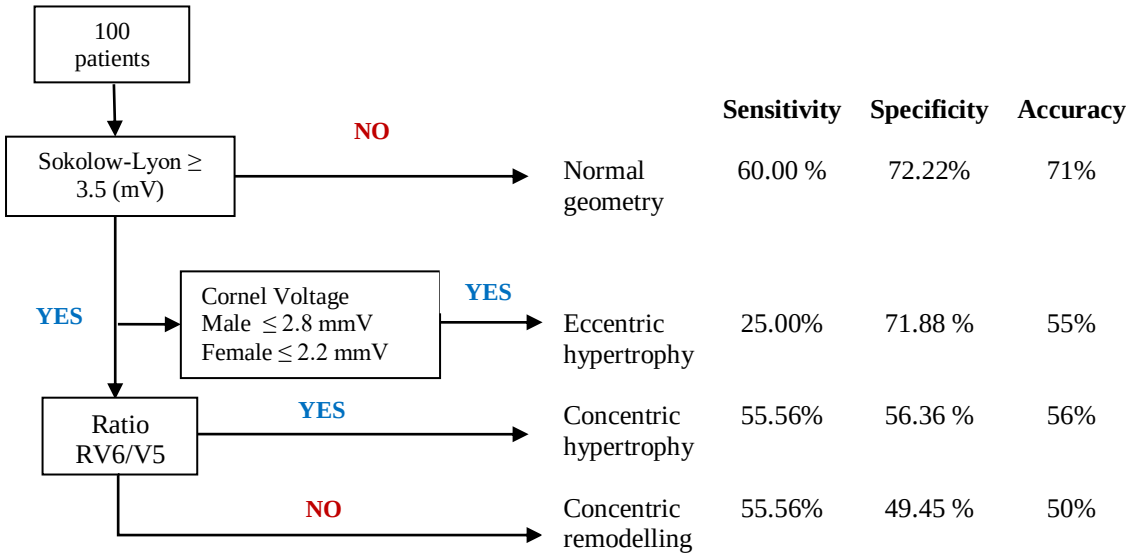

Figure 4. Flowchart identification of left ventricular hypertrophy geometry.

Sohaib et al[11] using cardiovascular magnetic resonance imaging (MRI) to determine left ventricular hypertrophy resulted in 50% sensitivity and 71.1% specificity for Sokolow-Lyon criteria, while for Cornel Voltage 25% sensitivity and 88.7% specificity. In the study of Ahnet al[12] found EKG criteria for left ventricular hypertrophy of Sokolow-Lyon criteria: sensitivity 3.3% and 95.6% specificity and Cornel Voltage: 6.6% sensitivity and 96% specificity. Ogunlade and Akintomide[13] found EKG criteria for left ventricular hypertrophy with Sokolow-Lyon criteria: sensitivity 58.62% and 60.66% and Cornel Voltage: sensitivity 51.72% and specificity 66.67%.

Criteria, The R ratio V6/V5, is rarely used because of its low sensitivity and specificity. Romhilt et al[14] obtained a sensitivity of 22.5% and a specificity of 89.5%. The research of Tomita et al[11] has 59% sensitivity and 30% specificity (RV6/V5>0.7).

In the systematic review by Pewsner et al.[15] of 21 studies on the accuracy of ECG criteria on left ventricular hypertrophy found various sensitivity and specificity values. It was concluded that the accuracy of the use of ECG criteria for LVH detection was unsatisfactory and the expected clinical implication was that the use of ECG criteria was important for immediate follow-up of examination such as echocardiography and laboratory for cardiovascular risk factors.

5. Conclusions

In this study, various left ventricular electrocardiographic voltage criteria to distinguish the left ventricular hypertrophy geometry type had weak sensitivity and specificity. Accuracy criteria Sokolow-Lyon and Cornel Voltage are better than RV6/V5 ratio criteria, but sensitivity and specificity are also weak.

References

[1] Devereux R and Roman M 1999 Left ventricular hypertrophy in hypertensive: stimuli, patterns, and consequences *Hypertens. Res*. **22** 1─9

[2] East M A, Jollis J G, Nelson M S, Marks D and Peterson E D 2003 The influence of left ventricle hypertrophy on survival in patients with coronary artery disease: do race and gender matter? *J. Am. Coll. Cardiol*. **41** 949─54

[3] Gerdts E, Cramariuc D, Simone G, Wachtell B and Devereux R 2008 Impact of left ventricular geometry on prognosis in hypertensive patients with left ventricular hypertrophy (the LIFE study) *Eur. Soc. Cardiol*. **9** 809─15
[4] Cacua K, Amell A and Cadavid F 2012 Effects of oxygen enriched air on the operation and performance of a diesel-biogas dual fuel engine *Biomass and bioenergy* **45(2)** 159-67
[5] Panggabean M 2009 Penyakit jantung hipertensi *Buku ajar ilmu penyakit dalam 4th edition* (Jakarta: Internal Publishing) pp 1265─7
[6] Kotchen T A 2010 Hypertensive vascular disease *Harrison's cardiovascular medicine* (McGraw-Hill) pp 429─35
[7] Mirtha D, Angel M, Nilvia A, Mayte D, Enrique D and Arturo M 2001 Prevalence of left ventricular hypertrophy in patients with essential high blood pressure *Argentine Fed. Cardiol.* 1─5
[8] Harter S, *et al*. 2012 Animals models of heart failure, a scientific statement *AHA* **111** 131-50
[9] Gaasch W and Zile M 2011 Left ventricular structural remodelling in health and disease *JACC* **58** 17
[10] Tomita S, Ueno H, Takata M, Yasumoto K, Tomoda and Inoue H 1998 Relationship between electrocardiographic voltage and geometric patterns of left ventricular hypertrophy in patients with essential hypertension *Hypertens. Res*. **21(4)** 259─66
[11] Sohaib S, Payne J, Shukla R, World M, Pennel D and Montgomery H 2009 Electrocardiographic (ECG) criteria for determining left ventricular mass in young healthy men; data from the LARGE heart study *J. Cardiovasc. Magnetic Resonance* **11** 2
[12] Ahn M, Yoo B, Lee J, Lee W, Youn Y, Ahn S, *et al.* 2015 Addition of N terminal pro B type natriuretic peptide levels to electrocardiography criteria for detection of left ventricular hypertrophy: The ARIRANG study *J. Korean Med. Sci.* **30** 407─13
[13] Ogunlade O and Akintomide A 2013 Assessment of voltage criteria for left ventricular hypertrophy in adult hypertensives in south-western nigeria *J. Cardiovasc. Dis. Res*. **4** 44─6
[14] Romhilt D, Bove K, Norris R, Conyers E, Conradi S, Rowland D, *et al.* 1969 A critical appraisal of the electrocardiographic criteria for the diagnosis of left ventricular hypertrophy *Circulation* **XL** 185─96
[15] Pewsner D, Juni P, Sundstrom J, Egger M, Battalia M and Bachman L 2007 Accuracy of electrocardiography in diagnosis of left ventricular hypertrophy in arterial hypertension: systematic review *BMJ* 1─9 doi:10.1136/bmj.39276.636354.AE.