Original Article

Comparative Study of Electrocardiographic and Echocardiographic Evidence of Left Ventricular Hypertrophy in Systemic Hypertension

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Abstract

BACKGROUND AND AIMS: Hypertension is a common health problem. Left ventricular hypertrophy, a condition in hypertension is a risk factor for myocardial infarction, stroke and heart failure. This study aims to detect left ventricular hypertrophy in hypertensive patients using Electrocardiography and echocardiography.

METHODS: In this descriptive cross-sectional study; 143 patients of Hypertension from February 2019 to August 2019 were enrolled. They were evaluated for left ventricular hypertrophy using electrocardiography and echocardiography. Sokolow-Lyon and Cornell Voltage electrocardiographic criteria were used and their sensitivities and specificities to detect left ventricular hypertrophy were calculated taking echocardiography as a gold standard method.

RESULTS: The mean age of the study population was 58.69±11.33 years. Mean duration of hypertension was 4.72 ± 3.2 years. The mean systolic and diastolic blood pressure were 137± 15.42 mmHg and 84±10.5 mmHg respectively. Out of 143 study population, 30(21%) of them had left ventricular hypertrophy on electrocardiography as defined by Sokolow-Lyon criteria, and 29(20.3%) had left ventricular hypertrophy on electrocardiography as per Cornell Voltage criteria. On combining both Sokolow-Lyon and Cornell Voltage criteria, 37(25.9%) of the study population had left ventricular hypertrophy on electrocardiography (either as per Sokolow-Lyon or Cornell Voltage criteria). On echocardiography, 62(43.4%) of them were found to have left ventricular hypertrophy.

CONCLUSIONS: Electrocardiography is a less sensitive tool to diagnose Left Ventricular Hypertrophy in hypertension but its specificity is high (>95%). Investigation of choice to detect Left Ventricular Hypertrophy in hypertensive people is still the echocardiography.

Introduction

Hypertension is a disease affecting about 65.4% of people aged over 60 years and is responsible for 6% of all deaths worldwide. Left ventricular hypertrophy (LVH) in hypertensive patients is common, readily detectable, and easily treatable condition. Left ventricular hypertrophy is considered as an important risk factor for adverse cardiovascular morbidity and fatal outcomes that can be detected by electrocardiography (ECG) and echocardiography (ECHO).[1]

The electrocardiogram is an easily available and cost effective tool to evaluate LVH. As compared to more specific tools like echocardiography, magnetic resonance imaging, and autopsy studies, efficacy of ECG is often questionable. Still, the two-dimensional echocardiography is referred to as the gold standard tool to evaluate for LVH.[2] If LVH is detected early, it helps in guiding therapeutic options to change the course of events to a significant measure.[3] Though the specificities of ECG criteria to find LVH are high (>90%), its sensitivities are in the lower range 20-60%.[4] Antihypertensive treatments which are aimed at

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reducing blood pressure (BP) can also produce regression of LVH, and prevention of progression to LVH. But the lower sensitivity of ECG as compared to other imaging modalities has been put as a limitation of ECG to diagnose LVH.[5]

So far there is still limited data in our setting that compare and correlate the ECG criteria with ECHO to find LVH. This study aims to compare different ECG LVH criteria and find out their sensitivity and specificity to diagnose LVH in hypertensive people taking ECHO as a gold standard method.

Methods

This is a descriptive cross-sectional comparative study conducted from February 2019 to August 2019. The study was conducted in the department of Internal Medicine of B. P. Koirala Institute of Health Sciences (BPKIHS), Dharan, a tertiary health care autonomous University of Eastern Nepal. Ethical clearance was obtained from Institutional review committee (IRC) of BPKIHS (Ref no: 413/075/076 IRC) before starting the study. Sample size calculated by purposive sampling method was one hundred and forty three. Written informed consent was taken from subjects before participating them on the study. Subjects were studied for presence or absence of LVH by doing ECG and ECHO.

Subjects meeting the case definition of systemic hypertension, who were 18 years of age or above and who gave written informed consent were included in the study. Known cases of Hypertension who were already taking antihypertensive treatment were also included. Subjects having conditions other than systemic hypertension that can cause LVH such as Aortic Stenosis, Hypertrophic Obstructive Cardiomyopathy, and Myocardial infarction were excluded from the study. Similarly, those with congenital heart diseases – Ventricular Septal Defect, Patent Ductus Arteriosus, Co-arctation of Aorta were excluded. Those having Left bundle branch block (LBBB) on ECG were also excluded

Systemic Hypertension was defined as the Systolic Blood pressure of ≥140 mmHg and diastolic Blood Pressure of ≥90 mmHg as per Joint National Committee (JNC) 7 definition.[6] Twelve lead ECG was done to the subjects at the paper speed of 25 mm/sec and at the calibration of 10mm. ECG criteria used to diagnose LVH were either Sokolow-Lyon Index or Cornell Voltage Criteria. LVH was defined as follows.

1. **Sokolow-Lyon Index** [7]

   Sum of S wave in V1 and R wave in V5 or V6 ≥ 3.5 mV (35 mm)

   And / or

   R wave in aVL ≥1.1 mV (11mm)

2. **Cornell Voltage Criteria** [8]

   For Male: Sum of S wave in V3 plus R wave in aVL > 2.8 mV (28mm)

   For Female: Sum of S wave in V3 plus R wave in aVL> 2.0 mV (20mm)

After obtaining ECG subjects meeting the inclusion criteria underwent M-Mode, 2-Dimensional (2D), colour flow and Pulsed Wave Doppler transthoracic Echocardiography by Phillips IE 33 echocardiography machine. Echocardiogram was obtained at rest in the lateral decubitus or supine position using parasternal and apical views. Left Ventricular septal wall thickness or Posterior wall thickness was measured at the end diastole immediately below mitral valve leaflets tip along parasternal long or short axis. Septal wall thickness or Posterior wall thickness > 10 mm in Male and > 9 mm in female was considered as LVH on Echocardiography.[9]

Data collection was done by using predesigned questionnaire in the medicine wards and OPD of BPHIKS. Demographic profile of study subjects -age, sex, address, family history of Hypertension, duration of Hypertension (for known case of Hypertension) was noted. ECG findings of LVH using Sokolow-Lyon Index and Cornell Voltage Criteria was recorded. Then these patients underwent Echocardiography where Echocardiographic evidence of presence or absence of LVH was noted.

Data were entered into Microsoft Excel 2010 & Statistical analysis was performed by using SPSS Programme 11.5 version. Quantitative data regarding the baseline characteristics were described with frequency, percentage, proportions, mean, standard deviation etc. Sensitivity, specificity, positive predictive value and negative predictive values to diagnose LVH using ECG and Echo were calculated. Receiver Operating Characteristic curve of different ECG criteria was plotted for sensitivity analysis.

Results

In Our Study a total of 143 hypertensive populations were enrolled. Around half of the study population (51.1%) were male. As shown in table 1, the mean age of the study population was 58.69±11.33 years. Mean duration of hypertension in the study population was 4.72 ± 3.2 years. Mean pulse rate was 77±9.54 beat per minute. Similarly mean systolic and diastolic blood pressure of the study population was 137± 15.42 mmHg and 84±10.5 mmHg respectively. Around 44.1% of the study population had family history of hypertension and 4.9% of them were found to have hypertension for the first time.

Table 1. Baseline Characteristics of the study Population (n=143)

Characteristic		n (%)
Age in years (mean ± SD*)		58.69 ± 11.33
Gender	Male	73 (51.1)
	Female	70 (48.9)
Age of male Population in years (mean ± SD)		58.22 ± 11.27
Age of female population in years(mean ± SD)		59.19 ± 11.46
Duration of Hypertension in years(mean ± SD)		4.72 ± 3.2
Family history of hypertension		63 (44.1)
Newly Diagnosed Hypertension		7 (4.9)
Pulse in rate per minute(mean ± SD)		77 ± 9.54
Systolic BP in mmHg** (mean ± SD)		137 ± 15.42
Diastolic BP in mmHg (mean ± SD)		84 ± 10.5
Duration of Hypertension in years	< 5	84 (58.74)
	5-10	46 (32.16)
	10-15	11 (7.7)
	>15	2 (1.39)

**SD=Standard Deviation, **mmHg=millimeter of Mercury*

Out of 143 study population, 30(21%) of them had left ventricular hypertrophy on ECG as defined by Sokolow-Lyon criteria, and 29 (20.3%) had left ventricular hypertrophy on ECG as per Cornell Voltage criteria. On combining both Sokolow-Lyon and Cornell Voltage criteria, 37(25.9%) were found to have left

ventricular hypertrophy on ECG (either by Sokolow-Lyon or Cornell Voltage criteria). On echocardiography 62 (43.4%) of study population were found to have left ventricular hypertrophy which is shown in table 2.

Table 2: Left Ventricular hypertrophy detected by Electrocardiography and Echocardiography (n= 143)

Diagnostic criteria	Left Ventricular Hypertrophy	
	Yes, n (%)	No, n (%)
LVH on ECG by Sokolow-Lyon criteria	30(21)	113(79)
LVH on ECG by Cornell Voltage Criteria	29(20.3)	114(79.7)
ECG LVH on combining both Sokolow-Lyon and Cornell Voltage Criteria	37(25.9)	106(74.1)
Echocardiographic LVH	62(43.4)	81(56.6)

Taking echocardiography as the gold standard method, sensitivity and specificity of different ECG criteria were calculated. As shown in the table 3, the sensitivity of ECG to detect LVH by Sokolow-Lyon criteria was 46.8% and specificity was 98.8%. Similarly Positive Predictive Value (PPV) and Negative predictive Value (NPV) for the same criteria was 96.6% and 70.7% respectively. Likewise sensitivity and specificity of ECG by Cornell Voltage to detect LVH was 40.3% and 95.1% respectively, and PPV and NPV for the same criteria was found to be 86.2% and 67.5% respectively. On combining both ECG criteria the sensitivity of ECG increased to 53.2% with specificity of 95.1%. PPV and NPV of the combined ECG criteria were 88.1% and 76.2% respectively.

Table 3: Sensitivity, Specificity, Positive Predictive Value(PPV), and Negative Predictive Value(NPV) of Diagnostic Criteria to diagnose LVH

Diagnostic Criteria	Sensitivity	Specificity	PPV	NPV
Sokolow-Lyon Criteria	46.8%	98.8%	96.6%	70.7%
Cornell Voltage Criteria	40.3%	95.1%	86.2%	67.5%
Combining Sokolow-Lyon and Cornell Voltage Criteria	53.2%	95.1%	88.1%	72.6%

Figure 1: ROC curve of Cornell Voltage criteria

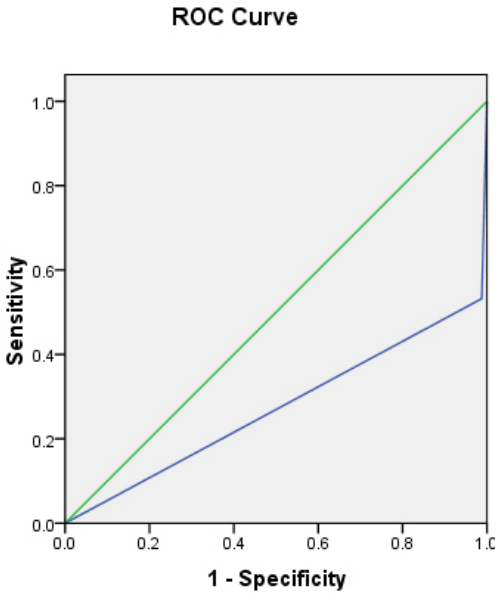
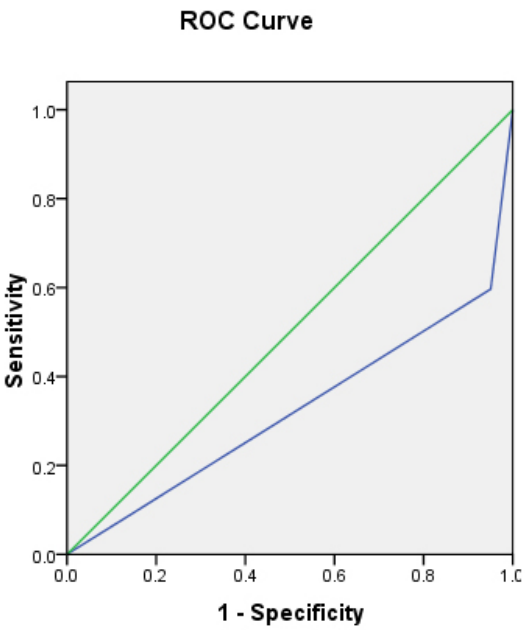
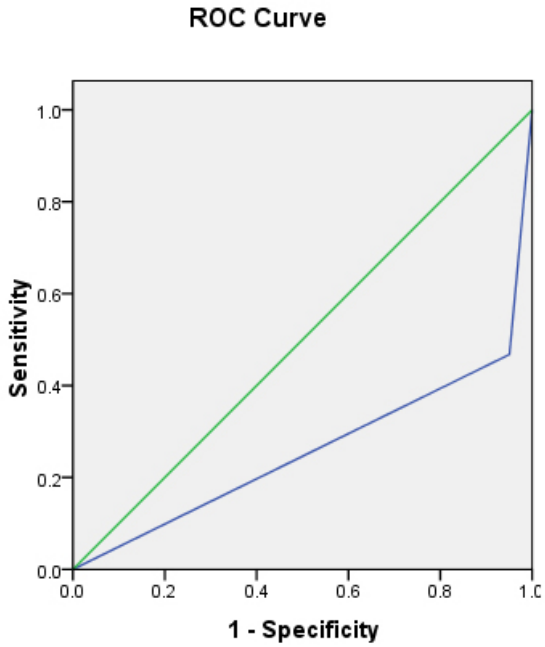


Figure 2: ROC curve of Sokolow-Lyon criteria



On plotting receiver operating characteristic (ROC) curve for Sokolow-Lyon criteria to detect LVH, the ROC curve, represented by the blue line as shown in figure 1 lied below the diagonal line and occupied area of 0.27 out of total area 1. Similarly, on plotting ROC curve for Cornell Voltage criteria to detect LVH, it also fell below diagonal line as shown in figure 2 and the curve occupied the total area of 0.32 out of 1. Likewise ROC curve for combined Sokolow-Lyon and Cornell Voltage was plotted which also lied below diagonal line and occupied area of 0.25 out of total area 1(on figure 3). These ROC curves have reflected the fact that LVH ECG criteria have low sensitivity.

Figure 3: ROC Curve of combined Sokolow-Lyon and Cornell Voltage Criteria.



Discussion

Left Ventricular hypertrophy is prevalent in about 25 percent of the hypertensive people. Still it remains undetected in about 50% of the Population. Of those in whom it is newly diagnosed, less than 50% are adequately treated. The heart has physiological mechanism of coping up for excessive afterload by myocyte hypertrophy. This compensatory change can sustain the excessive workload only up to a certain limit then after it fails. Effective antihypertensive therapy not only controls high blood pressure but also prevents the development of LVH.[3]

We detected LVH on ECG by Sokolow-Lyon criteria in 21% of the study population and its sensitivity was found to be 46.8% with 98.8% of specificity. This result was similar to a study done in India by G. Singh et al[4] in which they found sensitivity of Sokolow Lyon criteria to be 37%. Another study done in Taiwan by Su et al[10] found the sensitivity of Sokolow-Lyon to detect LVH to be 8.3%. The difference in result from our study was probably because they included only male population of 18 to 50 years of age who were free of hypertension. Other previous studies have determined the sensitivities of Sokolow-Lyon criteria in the range of 34% to 38% with specificities of >90% [4,2] Sokolow-Lyon in their original study found that the sensitivity of the Voltage criteria was 32% with 100% specificity.[7]

LVH on ECG by Cornell Voltage criteria was detected in 20.3% of study population. We found sensitivity of Cornell-Voltage criteria to detect LVH to be 40.3% with specificity of 95.3%, which was similar to study done by R.B. Devereux et al[11] which had sensitivity of 42% and specificity of 96%. In another study conducted by Molloy TJ[12], its sensitivity to detect LVH was 36%. Hanna EB et al studied sensitivity and specificity of ECG criteria for detection of LVH in patients with anterior wall myocardial infarction, and found that sensitivity of Cornell voltage criteria was 21% with 84 % of specificity[13] which was less than what we found in our results. We combined both sokolow-Lyon and Cornell voltage criteria that increased sensitivity of ECG to 53.2% with > 95% of specificity, which was similar to results obtained from previous study by Pinto J et al[1] where they had combined Sokolow-Lyon and Romhilt-Estes criteria and found sensitivity and specificity of ECG to be 60.9% and 85.2% respectively.

In our study, the prevalence of Echocardiographic LVH was 43.4% that was more than LVH detected by ECG criteria. This finding of our study was similar to the results from one of the previous studies done by Cuspidi C et al1[4] where they found the prevalence of LVH to be 41% by echocardiography. In another past study done by Martinez MA et al[15], they found frequency of echocardiographic LVH was 32% which was lower than the finding of our study. The discrepancy in the result was probably because they included patient of mild hypertension only in primary care.

Another study conducted in hypertensive patients by SM Ching et al[16] in Malaysia concluded that prevalence of echocardiographic LVH was 24%, which was also lower than our finding probably because they conducted study in primary care clinic and ours is tertiary referral centre where patients of severe hypertension were also included. A past study by Conrady AO et al[17] found a higher prevalence of echocardiographic LVH (ranging from 52.2% to 72.2%) than that of our study probably because they included more participants in their study than that of ours. In the same study they also suggested that age, sex, type of hypertension, duration of hypertension and obesity contributed to LVH. We plotted Receiver operating characteristic curve for sokolow-Lyon and Cornell voltage criteria and calculated the area under curve which came out to be 0.27 and 0.32 out of total area of 1 and curves lied below diagonal line. On combining both criteria, area under curve came out to be 0.25 out of 1 and curve lied below the diagonal line. This finding suggests that ECG has low sensitivity and can't be used for routine screening of LVH.

There are few limitations of our study. Presence or absence of Left Ventricular Hypertrophy was evaluated by echocardiography but left ventricular mass or left ventricular mass index was not calculated. Presence or absence of obesity was not evaluated which might affect the ECG to detect LVH in hypertensive people. Other ECG criteria to evaluate LVH like Romhilt-Estes Point scoring system was not assessed in our study which would have increased the ECG's sensitivity after combining it with Sokolow-Lyon and Cornell Voltage criteria.We recommend echocardiography as an investigation of choice to find LVH in hypertensive people. Due to low sensitivity, ECG can't be considered as screening tool to detect LVH in this population. However, ECG may be done as first line investigation to predict LVH where Echocardiography facility is not routinely available.

Conclusion

Electrocardiography is less sensitive tool to diagnose left ventricular hypertrophy in hypertensive people. The sensitivity of ECG to find left ventricular hypertrophy by Cornell Voltage criteria is 40.3% and by Sokolow-Lyon criteria is 46.8%. On combining both criteria sensitivity of ECG increased to 53.2%. Specificity of both criteria is high (>95%). Due to its low sensitivity, ECG can't be considered as screening method to detect LVH in hypertensive people. Investigation of choice to detect LVH in hypertensive population is still the echocardiography. Prevalence of Echocardiographic LVH in systemic hypertension is 43.4%.

Acknowledments

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Conflict of Interest: None

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