Assessment of the Sokolow Lyons Criteria of Left Ventricular Hypertrophy in Comparison with Echocardiography in Hypertensive Patients

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KEYWORDS

HYPERTENSION, LEFT VENTRICULAR HYPERTROPHY, ELECTROCARDIOGRAM, 2D ECHO, SOKOLOW LYONS CRITERIA

ABSTRACT

Around 65.4% of people over the age of 60 have hypertension, and it's the underlying cause of 6% of all fatalities globally. The left ventricle enlarges, or hypertrophies, in people with hypertension. If the left ventricle of the heart thickens its walls or the chamber of the left ventricle expands, or if both happen at once, the condition is called left ventricular hypertrophy (LVH) [1]. This condition impacts approximately 15 - 20% of the general population and has similar rates in men and women. Serious health complications such as cardiovascular diseases, stroke, congestive heart failure, irregular heart rhythms (ventricular arrhythmias), and sudden cardiac death are linked to it.

Rationale of the study: In people with slightly hypertensive conditions, the prevalence of LVH is 20%; in those with severe or complex hypertension, it approaches 100%. LVH is also a result of valve disorders, which cause pressure and/or volume overload. Furthermore, "physiological" LVH—which occurs in well-trained athletes in reaction to job overload—can arise. About 0.2% of the general population has hypertrophic cardiomyopathy, a hereditary condition caused by mutations in the sarcomere protein genes. It is characterized by severe cardiac tissue disarray, fibrotic scarring, and aberrant internal coronary arteries.

Background and statement of the problem: Hypertension is a leading cause of many cardiovascular problems and cerebrovascular accidents

Aim: Assessment of the Sokolowlyon's Criteria of Left Ventricular Hypertrophy in comparison with Echocardiography Inhypertensives Patients

Objective: To determine whether the ECHO of left ventricular hypertrophy significantly coincides with the Sokolow Lyon criterion of the ECG.

Methodology: This cross-sectional study was carried out at the Shree Balaji Medical College and Hospital's general medicine department in Chromepet, Tamil Nadu, India. The study ran from June 2022 to December 2023, a duration of eighteen months.

Results: The study focused on assessing the correlation between Sokolow-Lyon criteria on (ECG) and (LVH) as determined by echocardiography (ECHO). The results revealed that among the 125 participants, 88 cases (70.40%) were identified as having LVH based on Sokolow-Lyon criteria, while 37 cases (29.60%) showed no signs of LVH. These findings provide a quantitative breakdown of the prevalence of LVH according to ECG criteria within the study population.

Conclusion: Our investigation's findings showed that the ECG LVH Sokolow Lyon criteria had a satisfactory level of specificity and sensitivity in the diagnosis of left ventricular hypertrophy (LVH). The most sensitive diagnostic criteria turned out to be the ECG LVH Sokolow Lyon criteria, especially when it came to patients with co-morbidities. We found that the Sokolow Lyon criteria had a 36% sensitivity in the current investigation. As such, we suggest applying these criteria to assist in verifying the diagnosis of LVH, particularly in low-complexity healthcare environments without image-based diagnostic techniques like MRI and ECHO.

1. Introduction

Six percent of deaths globally are attributable to hypertension, which affects about 65.4% of people over 60. Left ventricular hypertrophy (LVH) is prevalent among hypertensive patients. LVH is the term for an increase in the mass of the left ventricle of the heart caused by either an expansion of the left ventricular chamber, an increase in wall thickness, or both [1]. About 15% to 20% of the general population is affected by it, and both men and women experience it at similar rates. Major health problems like stroke, ventricular arrhythmias, coronary artery disease, congestive heart failure, and sudden cardiac death have been related to it [2].

Hypertensive illness is the main cause of LVH, although there are other disorders and circumstances that can also contribute. In people with slightly hypertensive conditions, the prevalence of LVH is 20%; in those with severe or complex hypertension, it is about 100%. LVH is also a result of valve disorders, which cause pressure and/or volume overload. Furthermore, "physiological" LVH—which occurs in well-trained athletes in reaction to job overload—can arise. About 0.2% of the general population has hypertrophic cardiomyopathy, a hereditary condition caused by mutations in the sarcomere protein genes. It is characterized by severe cardiac tissue

disarray, fibrotic scarring, and aberrant internal coronary arteries [3].

It is categorized according to two main hemodynamic abnormalities: systolic and diastolic overload, sometimes known as pressure overload. Systolic overload occurs in circumstances like, conversely, results from left ventricular overfilling during diastole, compromising function during this phase. Volume overload, also referred to as left ventricular diastolic overload, is linked to moderate left-to-right shunt, aortic incompetence, and mitral incompetence [4].

Electrocardiography (ECG) and echocardiogram (ECHO) are two methods that can identify LVH. An inexpensive and readily available method for assessing LVH is the ECG. The effectiveness of ECG is sometimes questioned in comparison to more specialized instruments like magnetic resonance imaging, autopsy studies, and echocardiography. The gold standard method for evaluating for left ventricular hypertrophy is two-dimensional echocardiography. Early detection of LVH aids in directing treatment options to significantly alter the course of events.[5]

Electrocardiograms, or ECGs, can change the heart's electrical activity and reveal signs of left ventricular hypertrophy. While echocardiography remains the gold standard for measuring heart size and evaluating left ventricular hypertrophy (LVH), ECG is a cost-effective and widely available supplementary screening technique [6]. The most used ECG voltage criteria to evaluate LVH are the traditional Cornell Voltage Criteria (CVC) and Sokolow-Lyon Index (SLI), as well as the more modern Peguero-Lo Presti Criteria and Romhilt-Estes Criteria (REC) score [7]. The Sokolow-Lyon voltage criteria are frequently used in LVH assessment to define LVH based on specific amplitude thresholds and product requirements. The Sokolow-Lyon voltage is the result of adding the amplitudes of S in V1 and R in V5 or V6 $\geq$3.5 mV.

Echocardiography is a suitable diagnostic tool for suspected hypertensive heart disease. It is more accurate in identifying asymptomatic organ damage, which is useful in calculating one's risk of cardiovascular disease. Echocardiography is primarily used to evaluate LVH in hypertensive 2 patients, with an emphasis on mass and geometry measurements. When it comes to identifying LVH, echocardiographic evaluation is noticeably more sensitive than electrocardiography [10].

According to Dhodar et al. [5], the ECG exhibits a higher specificity (>95%) but a lesser sensitivity when it comes to detecting left ventricular hypertrophy (LVH) in hypertension, whereas the Sokolow-Lyon criterion has a sensitivity of 46.8%. The preferred method for detecting LVH in hypertensive individuals, according to the results, is still echocardiography. Mohan G. et al.'s comparison of diagnostic accuracy [4] revealed that the Sokolow criterion is significantly more accurate in detecting LVH than the Cornell and Romhilt-Estes criteria. However, because of their reduced sensitivity, Sokolow-Lyon ECG criteria alone are considered insufficient as screening tools, requiring additional assessment by echocardiography [11]. In clinical practice, echocardiography is commonly considered the gold standard for LVH identification. Nonetheless, because of its affordability, ease of use, and simplicity, ECG is still commonly used. At the moment there is limited data in our setting comparing and correlating ECG criteria with echocardiography to diagnose LVH. Thus, the purpose of this research was to estimate the relationship between echocardiography and Sokolow-Lyon's LVH criteria in hypertension patients.

2. Materials and Methodology

This cross-sectional study was carried out in the Department of General Medicine at Shree Balaji Medical College and Hospital, located in Chromepet, Tamil Nadu, India. The study spanned over a period of 18 months, from June 2022 to December 2023.

Study Population: This study included hypertensive patients aged 18-60 years attending both the Inpatient Department (IPD) and Outpatient Department (OPD) of the Department of General Medicine at Shree Balaji Medical College and Hospital, located in Chromepet, Tamil Nadu, India.

Inclusion Criteria

1. Hypertensive patient’s age group 18-60 years attending the OPD and IPD of the Department of General Medicine, Shree Balaji Medical College and Hospital.
2. This study comprised hypertensive patients diagnosed with Left Ventricular Hypertrophy on an ECHO.
3. Patients willing to sign an informed consent form.

Exclusion Criteria

All secondary causes of HTN.

Patients who were not ready to give consent were excluded.

On the basis of inclusion criteria total 125 patients were taken for the study. A detailed clinical history of patients were taken including age, sex, duration of illness, any other predisposing events and any furthermore, prior treatment taken was noted down.

Firstly, the patient's general clinical examination was taken. Clinical examination included the clinical findings of pulse, blood pressure and cardiovascular examination were recorded. A thorough general physical examination and a systemic assessment were conducted, which included calculating the body mass index (BMI) using the Quetelet index ([weight (kg)/height (m2)]) and determining the body surface area (BSA) using the Mosteller formula ([BSA(m2) = ([height (cm) × weight (kg)]/3600)1⁄2]). Patients were placed in a comfortable supine position and a standard 12-lead electrocardiogram (ECG) was recorded. Before recording, the ECG machine was calibrated with a paper speed of 25 mm/sec and a stylus deflection amplitude of 1 mV/cm. Using the Sokolow-Lyon criterion, which measures the amplitude of the S wave in lead V1 and the amplitude of the R wave in lead V5 or V6 (whichever is larger), LVH was evaluated on the ECG. Sokolow-Lyon standard: R in a VL >11 mm = 35 mm + S in V1 + R in V5 or V6.

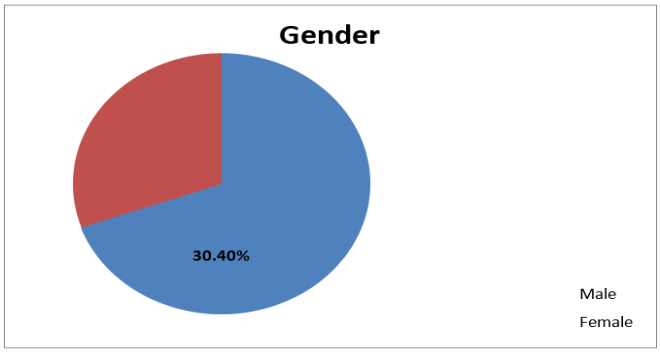
Measurements were made with the echocardiography machine's 6S probe (2.7-8.0MHz) when the heart was visible in the long-axis view. The American Society of Echocardiography devised a method for determining left ventricular mass (LV mass) by measuring the interventricular septum thickness (IVS), left ventricular posterior wall thickness (LVPW) and left ventricular internal diameter (LVID). The ratio of LV mass to BSA was then used to compute the LV mass index, or LVMI. All information is gathered into an Excel spreadsheet. After that, echocardiography and the ECG Sokolow-Lyon criterion were compared.

3. Results

Table 1: Demographics of the study group participants

Variables	No of cases	Mean ± SD
Age	125	42.49 ± 10.37
Gender		
Male	87	69.60%
Female	38	30.40%
left ventricular mass index (Mean ± SD)		196 ± 79

In the study of the correlation between Sokolow-Lyon criteria on electrocardiogram (ECG) and LVH as assessed by echocardiography (ECHO) the study group comprised 125 members with a mean period of 42.49 ± 10.37 years. The gender distribution included 87 males (69.60%) and 38 females (30.40%). left ventricular mass index, which exhibited a mean value of 196 ± 79g.



Graph 1: Gender distribution in the study group

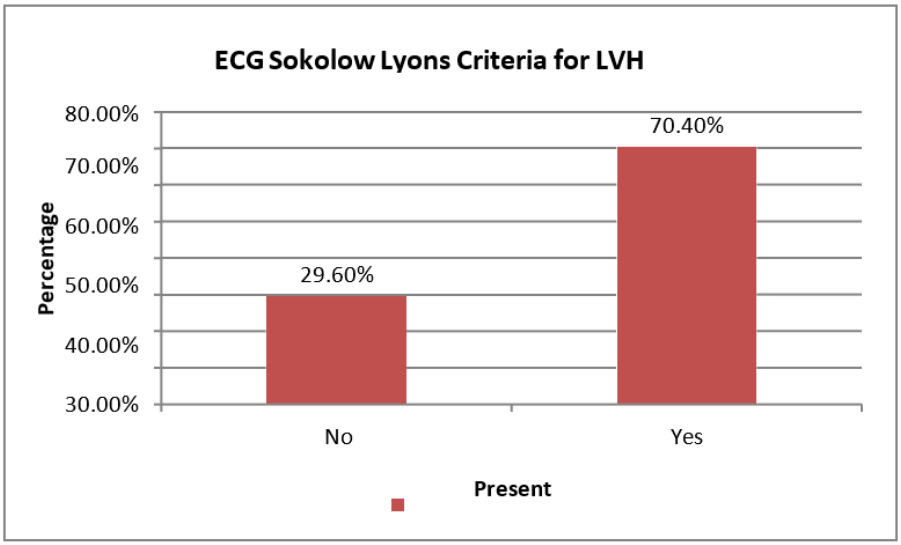
Table 2: left ventricular hypertrophy identified through 2D Echo

2D Echo	No of cases
Present	125

The dataset comprised 125 cases where left ventricular hypertrophy was identified through 2D Echo. The Sokolow-Lyon criteria on ECG were then examined to ascertain their alignment with the echocardiographic confirmation of LVH.

Table 3: ECG Sokolow Lyons Criteria for LVH

Present	No of cases	Percentage
No	37	29.60%
Yes	88	70.40%
Total	125	100.00%

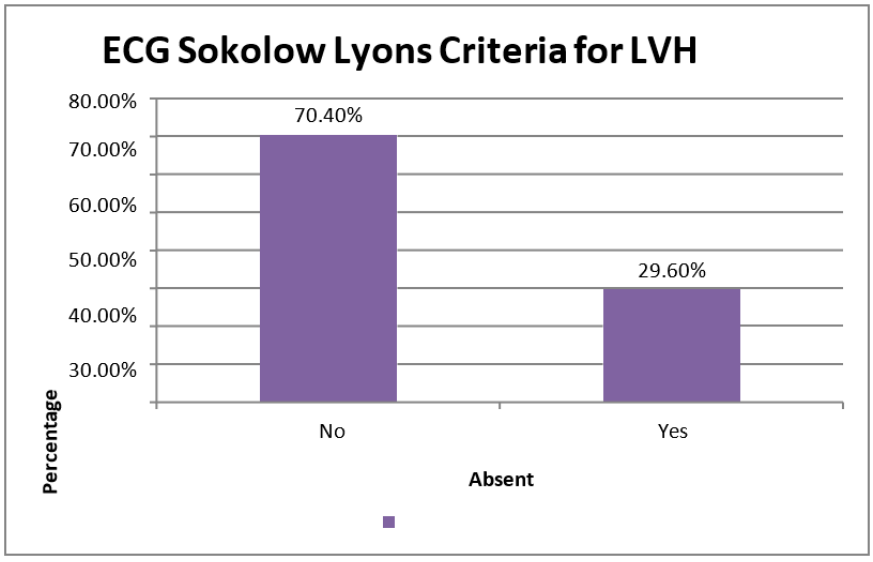


Graph 2: ECG Sokolow Lyons Criteria for LVH

The study focused on assessing the correlation between Sokolow-Lyon criteria on (ECG) and (LVH) as determined by echocardiography (ECHO). The results revealed that among the 125 participants, 88 cases (70.40%) were identified as having LVH based on Sokolow-Lyon criteria, while 37 cases (29.60%) showed no signs of LVH. These findings provide a quantitative breakdown of the commonness of LVH as per ECG standards inside the review populace.

Table-4: ECG Sokolow Lyons Criteria for LVH

ECG Absent	No of cases	Percentage
No	88	70.40%
Yes	37	29.60%
Total	125	100.00%



Graph-3: ECG Sokolow Lyons Criteria for LVH

The presented data showed to the application of Sokolow-Lyon criteria within a study population of 125 participants. The results showed that among the total cases, 88 individuals (70.40%) did not exhibit Sokolow-Lyon criteria for LVH on their ECGs, while 37 cases (29.60%) were identified as having LVH.

Table-5: Correlation

Correlation	No of cases	Percentage
Absent	37	29.60%
Present	88	70.40%
Total	125	100.00%

Table-6: Comparison /correlation of ECG Sokolow Lyons Criteria for LVH (Present)

Present	LVH	
	Yes	**No**
Variables		
Age	42.35 ± 9.78	42.83 ± 11.81
Gender		
Male	62	25
Female	26	12
Correlation		
Present	0	37
Absent	88	0

The data presented here show the results of a comparison/correlation study of the age-gender-LVH Sokolow-Lyon criteria for electrocardiograms (ECGs). The mean age for individuals with ECG-detected LVH (Present) was 42.35 ± 9.78, while those without LVH had a slightly higher mean age of 42.83 ± 11.81. Gender distribution showed that among males, 62 had ECG- detected LVH, while 25 did not. Among females, 26 had LVH on ECG, and 12 did not.

Table-7: Comparison /correlation of ECG Sokolow Lyons Criteria for LVH (Absent).

Absent	Yes	No
Variables		
Age	42.83 ± 11.81	42.35 ± 9.78
Gender		
Male	25	32
Female	12	26
Correlation		
Present	0	88
Absent	37	0

The presented data showed a comparative analysis and correlation assessment of ECG Sokolow-Lyon criteria for LVH specifically when the criteria are absent. In cases where LVH was not detected on ECG (Absent), the mean age was slightly higher at 42.83 ± 11.81 compared to 42.35 ± 9.78 for those with ECG-detected LVH. Gender distribution showed that among males, 25 had no LVH on ECG, while 32 had LVH. Among females, 12 had no LVH on ECG, while 26 did.

Table 8: The Sokolow-lyon criterion's specificity and sensitivity for LVH detection.

Sokolow-Lyon	Value
Sensitivity (%)	36%
Specificity (%)	94%
Kappa coefficient	-0.018
P value	0.32

4. Discussion

Early identification is critical for left ventricular hypertrophy (LVH), which arises as the heart adapts to increased hemodynamic load. As a first line of diagnosis for LVH, the 12-lead electrocardiogram (ECG) is often used; however, its sensitivity is sometimes inadequate. Echocardiography, on the other hand, has been used in clinical settings for more than 30 years and has become an important non-invasive imaging tool for evaluating the design and capability of the heart.

A total of 125 hypertension individuals, with an average age of 42, were included in this research. Of these

patients, 87 were male (or 69.60%) and 38 were female (or 30.40%). According to the echocardiographic results, all 125 patients were diagnosed with LVH.

Comparatively, a study by **Altaweel RB et al., [68]** reported a mean age of 50.4 ± 10.2 years among participants, with 57.86% male and 42.14% female. As for the average BMI (31.7 ± 4.2 kg/m²) and BSA (1.94 ± 0.3 m²), those values were taken from the same source. Echocardiographic results indicated that 83 patients (59.29%) had LVH, while 40.71% did not.

Similarly, a study by **Sebastian G et al., [69]** included 102 hypertensive patients, 80 guys and 22 females. The typical mass of the left ventricle (LVM) was 237 g for men and 160 g for ladies. That's what results showed women had a mean LVMI of 102 g/m² and men 141 g/m². According to echocardiographic criteria, 86% of men and 72% of ladies had genuine LVH. For all kinds of people, the Sokolow-Lyon model was the most sensitive, while the Cornell criterion was the most specific. Nevertheless, in hypertensive patients, none of the three electrocardiogram criteria—the Cornell voltage, the Sokolow-Lyon, and the Romhilt-Estes point score—were shown to be useful screening tests for LVH.

The buildup of fibrous tissue that is not electrically active causes left ventricular mass to rise with age, particularly in the elderly. The ECG anomalies that are often associated with left ventricular hypertrophy (LVH) in older people may be due more to conduction faults than an increase in muscle tissue, which makes the ECG diagnosis of LVH less reliable. **Singh G et al., [70]** have noted the low sensitivity of ECG-based tests for LVH in the elderly population, although few epidemiological studies have focused specifically on this demographic.

A sum of 125 hypertension patients (mean age: 42) were remembered for the examination, which looked at the Sokolow-Lyon rules for LVH involving echocardiography as the highest quality level for diagnosis. Men made up 87 (or 69.60%) of the 125 cases, while females accounted for 38 (or 30.40%). Among the 125 patients, 88 cases were identified as having LVH based on the Sokolow-Lyon criteria. It was observed that ECG was more sensitive in males (62) compared to females (26). This finding aligns with a study by **Mohan G et al.,** [4] The results showed that electrocardiogram (ECG) sensitivity was higher in men (51.06%) contrasted with ladies (36.63%), and that the diagnostic accuracy was 52% in men and 44% in women.

Additionally, **Salamaga et al., [71]** 37 patients, with an average age of 42.35 years, were found to meet the Sokolow-Lyon criteria for LVH, constituting 29.60% of the total. The Sokolow-Lyon criteria had a specificity of 88.80% for women and 71.88% for males in a Brazilian population studied by Gasperin et al.

The Sokolow-Lyon criteria were the most sensitive in this investigation for detecting LVH even when other comorbidities were present. The lack of agreement between electrocardiogram (ECG) and echocardiogram (ECHO) in LVH diagnosis was supported by a Kappa proportion of understanding of 0.018. The awareness and particularity for this measures were 36% and 94%, respectively. Martin et al. [72] also found something similar; they had a 75% specificity rate and a Kappa coefficient that were quite similar. In a similar vein, Golla A et al., [73] discovered that the Sokolow-Lyon criteria were 94% specific and 35% sensitive. The Romhilt-Estes and Sokolow-Lyon criteria were determined to have the greatest accuracy, sensitivity, and specificity, respectively, by Krittayaphong R et al., [74]..

One limitation of this study is that MRI might have served as a superior standard tool compared to ECHO-based assessment. There was also no comparison between LVH assessments using M-mode and those using electrocardiogram or two-dimensional echocardiography.

5. Conclusion

Research conducted by our group has shown that the ECG LVH Sokolow Lyon criteria are quite sensitive and specific in identifying LVH. In circumstances when patients had many medical conditions, the ECG LVH Sokolow Lyon criteria proved to be the most accurate way to diagnose heart problems. We found that the Sokolow Lyon criteria were 36% sensitive in this investigation. So, to help establish LVH, we suggest using these criteria, particularly in low-complexity healthcare settings without image-based diagnostics like ECHO and MRI.

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