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# Left ventricular hypertrophy in hypertensive patients: Prevalence and diagnosis

Amanj A. Khaznadar, Farman J. Ahmed, Kawa Tahir, Fahmi H. Kakamad

## ABSTRACT

**Aims: Left ventricular hypertrophy is an important predictor of cardiovascular risk, and its detection contributes to risk stratification. The aims of the study were to evaluate the prevalence of left ventricular hypertrophy in hypertensive patients and to assess the accuracy of electrocardiography in its diagnosis. Methods: A single center based, prospective, cross sectional study was carried out for a period of eight months. The data were collected through direct interview and fulfilling of a prepared questionnaire. Besides these, all patients were sent to do electrocardiography and echocardiography. Results: Mean age was 62.7±7.8 years, females (58%) were more than males (42%). Mean BMI of (28.38±2.9 kg/m²), (30%) of the patients with hypertension were found to have left ventricular hypertrophy. Sensitivity/specificity of Sokolow-Lyon voltage, Cornell voltage and strain pattern were 30/89, 25/93, 20/96 respectively. Conclusion: Prevalence of left ventricular hypertrophy was 30% in hypertensive patients, Electrocardiography cannot be used as the screening tool for the diagnosis of left ventricular hypertrophy.**

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

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## INTRODUCTION

Left ventricular hypertrophy (LVH) is defined by the increased left ventricular mass; with myocardial cell hypertrophy and an increase in collagen within myocardium [1]. Multifactor etiology for LVH has been implicated including, age, sex, body size, blood pressure and diabetes [2].

Age, race, gender and body size can influence cardiac mass; this might occur through cardiac load [3]. Hypertensive LVH is a risk factor for high insulin level and insulin resistance. Significant correlation between left ventricular mass, insulin-like growth factor–I (IGF-I) and insulin was observed in a cohort study [4]. Correlation between LVH in first-degree relatives than in second-degree relatives or couples is shown in analyzing of left ventricular mass heritability in the Framingham Heart Study, suggesting that about 30% of left ventricular mass variance is determined by genetic [5].

Pathological changes induced by chronic pressure overload include an increase in the size of the cardiac myocytes, changing composition of the extracellular matrix with increase of collagen fibers and abnormal changes in intramyocardial coronary vessels [6]. However, most attention has been put on risk factors associated with LVH, and on the beneficial effects of pharmacological treatment, as there is detrimental contribution of LVH to cardiovascular events and survival [7].

Physical examination may show signs of hypertension and LVH like high blood pressure measurement, augmented aortic sound on auscultation and displaced cardiac impulse palpation. Yet, ECG may be an effective tool in the diagnosis of LVH [8]. Precordial leads may show a negative P wave, anterior leads may have large QRS amplitudes while lateral leads demonstrating deep S and high R as a consequence of LVH. The most popular ECG criteria are the Cornell voltage, the Cornell product, the Sokolow-Lyon index and the Romhilt-Estes point score system [8–11] (Table 1). Electrocardiography (ECG) limitations are; first, variable diseases present with near similar changes. Second, inaccuracy in some patients like morbid obesity and emphysematous chest. Echo, if available, should be the test of choice to assess for LVH and detect other abnormalities such as left ventricular dysfunction and valvular disease [12].

Cardiac magnetic resonance imaging (MRI) scan is more accurate for measuring left ventricular mass and is assessed in well-designed epidemiological and clinical studies but ECG and Echo are the cheapest and most readily available tests for LVH [13].

The development of LVH leads to left ventricular diastolic dysfunction, an important factor in the evolution of congestive heart failure. Furthermore, interstitial myocardial fibrosis and an increased myocardial mass reduce coronary flow reserve leading to impaired tolerability and myocardial ischemia [14]. Also there is enough evidence showing that LVH causes arrhythmia [15].

The aim of this study is to evaluate and show the prevalence of LVH in hypertensive cases and to assess the accuracy of ECG in diagnosing LVH.

## MATERIALS AND METHODS

### Study design and settings

A cross sectional study was carried out at in single center for a period of eight months, from 1st of February 2016, to 1st of October 2016, all patients underwent ECG and transthoracic Echo.

Inclusion criteria: All hypertensive patients, free from exclusion criteria, during the study period, were included.

Exclusion criteria: Cor pulmonale, myocardial infarction, valvular heart disease, bundle branch blocks, pre-excitation syndrome and cardiomyopathy are excluded.

### Intervention and data collection

The data were obtained from the patient's case notes and through direct questioning. Physical examination of each patient was carried out including precordial examination and taking blood pressure in a proper way. All patients underwent ECG and Echo. The estimation of left ventricular mass (LVM) was based on the formula derived by Devereux et al. [12].

$$LVM = 0.8\ (1.04\ [(LVIDd + PWTd + IVSTd)^3 - (LVIDd)^3]\ ) + 0.6\ g$$

where, LVIDd = Left ventricle internal dimension in diastole

PWTd = Posterior wall thickness in diastole,
IVSTd = Interventricular septal thickness in diastole,
1.04 = specific gravity of the myocardium.

Also by incorporating height and weight, LVM index calculated, LVM index was defined as LVM divided by body surface area (LVM/BSA, g/m$^2$). BSA was calculated according to the formula:

$$BSA = 0.6 \times height\ (m) + 0.0128 \times weight\ (kg) - 0.1529.$$

Left ventricular hypertrophy was defined by LVM of ≥ 162 grams for women and ≥224 grams for men, or LVM index of ≥ 95 g/m$^2$ for women and ≥115 g/m$^2$ for men and graded according to Table 2.

### Ethical considerations

- Approval was taken from Kurdistan Board of Medical Specialty and Sulaimany Directorate of Health.
- Oral consent was taken from each patient and they were assured about their Confidentiality.

### Statistical analysis

Data analysis was done by computerized statistical software; Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistics presented as (mean±standard deviation) and frequencies as percentages. Normality of the data set was verified. Multiple contingency tables conducted and appropriate statistical tests were performed, chi-square test was used for categorical variables and independent *t*-test was used to compare between means. In all statistical analysis, level of significance (p-value) was set at ≤ 0.05.

## RESULTS

### Clinical and demographical characteristics

The study included 200 patients, 84 (42%) cases were male and 116 (58%) patients were female, the age ranged between 50–80 years with mean age of 62.7±7. Table 3

Table 1: Common electrocardiography criteria for the diagnosis of left ventricular hypertrophy [8–10]

| | |
|---|---|
| Cornell voltage criteria | SV3 + RaVL ≥ 2.8 mV (28 mm) in men<br>SV3 + RaVL ≥ 2.0 mV (20 mm) in women |
| Cornell product criteria | SV3 + RaVL (+8 in women a) x QRS duration ≥ 2,440 mm × ms |
| Sokolow-Lyon voltage criteria | SV1 + RV5 or RV6 ≥ 3.5 mV (35 mm) b<br>or RaVL ≥ 1.1 mV (11 mm) |
| Romhilt-Estes (point score system) | (a score ≥ 5 is diagnostic of LVH, a score of 4 is "probable" LVH)<br>Voltage criteria (3 points): Any S or R in limb leads ≥ 20 mm SV1, SV2, RV5, or RV6 ≥ 30 mm ST-T wave changes of LVH (3 points, 1 point on digitalis)<br>Left atrial abnormality (3 points): Terminal component of the P wave in V1 ≥ 1 mm and ≥ 40 ms<br>Left axis deviation (2 points): QRS axis of −30 degrees or more negative Prolonged QRS duration (1 point): ≥ 90 ms<br>Delayed intrinsicoid deflection time (1 point): ≥ 50 ms in V5 or V6 |

gives information about socio-demographic characteristic and risk factors of the patients.

## Echo findings

Sixty (30%) patients revealed LVH, among them 39 (65%) patients were female and 21 (35%) patients were male. Eighteen (9%) patients had left ventricular systolic dysfunction, 54 (27%) patients had left ventricular diastolic dysfunction. Table 4 gives details of ECG findings of the patients.

The prevalence of LVH was significantly higher in female, and eccentric type was significantly more prevalent in female as given in Table 5.

## ECG findings

Thirty-three (16.5%) patients had voltage criteria of Sokolow-Lyon voltage, 25 (12.5%) patients had voltage criteria of Cornell voltage, and 18 (9%) patients had left ventricular strain pattern.

The calculated sensitivity/specificity for the ECG findings in patients with LVH for Sokolow-Lyon criteria was 30%/89%, for cornel voltage was 25%/93% and for left ventricular strain pattern was 20%/96% respectively (Table 6 and Table 7).

## DISCUSSION

Left ventricular hypertrophy is associated with increased cardiovascular morbidity and mortality, so its

Table 2: Left ventricular hypertrophy grading [16]

| | Mild | Moderate | Severe |
|---|---|---|---|
| Left ventricular mass/ BSA (g/m²) | 96–108 | 109–121 | ≥122 |
| Women | | | |
| Left ventricular mass/ BSA (g/m²) | 116–131 | 132–148 | ≥149 |
| Men | | | |

Table 3: Socio-demographic characteristics of patients

| Variable | No. |
|---|---|
| **Age** | |
| 50–59 | 62 (31%) |
| 60–69 | 94 (47%) |
| ≥70 | 44 (22%) |
| Male | 84 (42%) |
| Female | 116 (58%) |
| Weight mean±SD (76.34±10 kg) | |
| Height mean±SD (162± 7.2 cm) | |
| BMI mean±SD (28.38± 2.9 kg/m²) | |
| Anti-hypertensive treatment | 140 (70%) |
| **Duration of hypertension** | |
| 1–5 years | 62 (31%) |
| 6–10 years | 94 (47%) |
| 11–15 years | 32 (16%) |
| ≥16 years | 12 (6%) |
| Mean systolic blood pressure | 158.45 |
| Mean diastolic blood pressure | 87.67 |
| Mean MAP | 110.76 |
| Diabetes mellitus | 26 (13%) |
| Smoking history | 42 (21%) |

Table 4: Echo findings of the patients

| Echocardiographic finding | No. |
|---|---|
| No left ventricular hypertrophy on echocardiography | 140 (70%) |
| Left ventricular hypertrophy on echocardiography | 60 (30%) |
| Systolic dysfunction | 18 (9%) |
| Diastolic dysfunction | 54 (27%) |
| Eccentric left ventricular hypertrophy | 40 (20%) |
| Concentric left ventricular hypertrophy | 20 (10%) |
| Mild left ventricular hypertrophy | 38 (19%) |
| Moderate left ventricular hypertrophy | 15 (7.5%) |
| Severe left ventricular hypertrophy | 7 (3.5%) |

Table 5: Gender specific difference in geometry of left ventricular hypertrophy (LVH)

| Type of LVH | Gender | | p-value |
|---|---|---|---|
| | Male | Female | |
| LVH (ALL) | 21 (10.5%) | 39 (19.5%) | <0.05 |
| Eccentric LVH | 14 (7%) | 26 (13%) | <0.05 |
| Concentric LVH | 12 (6%) | 8 (4%) | >0.05 |

Table 6: Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of electrocardiography in comparison to echo regarding diagnosis of left ventricular hypertrophy

| Criteria | Sensitivity | Specificity | Accuracy | Positive predictive value | Negative predictive value |
|---|---|---|---|---|---|
| Sokolow-Lyon voltage | 30% | 89% | 71% | 55 | 75 |
| Cornell voltage | 25% | 93% | 72% | 60 | 74 |
| Strain pattern | 20% | 96% | 73% | 67 | 73 |

Table 7: Gender difference in sensitivity, specificity of electrocardiography

| Criteria | Female | | | Male | | |
|---|---|---|---|---|---|---|
| | Sensitivity | Specificity | p-value | Sensitivity | Specificity | p-value |
| Sokolow-Lyon voltage | 35.9% | 87% | 0.007 | 19% | 90.5% | 0.2 |
| Cornell voltage | 28.2% | 90.9% | 0.032 | 19% | 95.2% | 0.062 |
| Strain pattern | 20.5% | 93.5% | 0.013 | 19% | 98.4% | 0.013 |

diagnosis is critical, especially for hypertensive patients [16]. Echo criteria for LVH have been shown to have excellent sensitivity, specificity and accuracy when compared with postmortem left ventricular mass, and its reliability has been confirmed angiographically [17]. Based on the population studied and the criteria used for LVH, the prevalence of LVH in hypertensive cases varies from 20–70% in the most studies worldwide [18–20]. In one meta-analysis of Cuspidi et al. of 30 studies published in the last decade provides one of the largest data base on echo LVH prevalence in a hypertensive population of 37700 patients from different hypertensive cohorts and from the hypertensive fraction of the general population. Left ventricular hypertrophy is present in approximately 36% of the pooled population according to more restrictive diagnostic criteria. In another meta-analysis by Pewsner et al. who analyzed 5608 patients in 21 studies, the median prevalence of LVH was 33% (interquartile range 23–41%). In the current study, the prevalence of LVH was 30%, this result is very close to the results of de Simone et al. and Fesler et al. which were 31% and 33% respectively [21–24]. Majority of our patients were female. The data were taken consecutively. Whether it occurred by chance or hypertensive is more prevalent among female in our locality is not known.

As for left ventricular geometric patterns, the eccentric pattern was more prevalent than the concentric one in 14 out of 18 studies in the pre-mentioned meta-analysis, the same proportion was also obtained in this study in which eccentric LVH was 20% while concentric LVH was 10% [21].

There are too much controversies regarding relationship between gender and LVH. There are studies that showed that females have a positive association with LVH. However, other studies confirmed the reverse of this. At the same time, another series showed that there is no difference between gender and LVH [24–30]. This current series showed that the female gender is a predictor for the development of LVH with an odd ratio of 1.182.

Many studies found that patients with obesity are at risk of developing LVH [31–33]. This study supports these findings with odd ratio of 1.2 for patients with BMI more than 25 compared with a patient who has normal weight at a 95% confident interval of 0.07–2.08. The remodeling process in long-standing hypertension consists of hypertrophy, fibrosis and impaired microvascular circulation with arterial stiffness is accompanied by higher pulse pressure and systolic blood pressure, which are well-known risk factors for cardiovascular diseases [34]. Few studies have assessed the relationship between LVH and cigarette smoking. In the LIFE study, smoking was more common among LVH patients in comparison to control [35]. In the current study, there was no association between LVH and smoking. For the last decade, many studies have been conducted regarding ECG diagnosis of LVH based on ECG criteria [36–42].

The criteria were used to increase the accuracy of the method for diagnosing LVH. In this study, sensitivity of all criteria was low (20–30%).

In the present study, three applicable ECG criteria for LVH diagnosis in hypertensive cases with Echo as the diagnostic standard. Sokolow-Lyon criteria are the oldest criteria revised by Sokolow and Lyon in 1949. It is the oldest, quickest and simplest method for diagnosis of LVH by ECG. According to this study, it has sensitivity of 30%, specificity of 89 %, positive predictive vale (PPV) of 55%, negative predictive vale (NPV) of 75% and accuracy of 71%.

The specificity and sensitivity of Sokolow-Lyon criteria showed different results in different studies, in our study it was very close to the sensitivity/ specificity of Norman et al. (1995) and Jaggy et al. (2000) which were 30%/86% and 31%/86% respectively [36, 37].

In assessing Cornell voltage criteria, sensitivity of 25%, specificity of 93%, PPV of 60%, NPV of 74% and accuracy of 72%.

The sensitivity/specificity of Cornell voltage criteria in the current study was close to Salles et al. which were 24%/89% respectively while the sensitivity of our study was far more than the results of Fragolaw which was 8% and a higher score obtained in Calacaw which was 41% [38–40].

In assessing the scores for left ventricular strain pattern, sensitivity of 20%, specificity of 96%, PPV of 67%, NPV of 73%, accuracy of 73%.

There is wide range among studies in evaluation of sensitivity of left ventricular pattern, sensitivity ranging from 11.9–38.6%. Our study took a median position among them and it was very close to Sundström et al. 88 in which sensitivity was 21% and specificity was 92%.

Alfakih et al. analyzed the value of gender specific partition for ECG criteria of LVH recalibrated against cardiac MRI scan, and evaluated that Cornell voltage criterion had highest sensitivities in males (26.2%) as compared to females (16.3%), while the reverse was found in Sergio et al., who assessed both the specificity and sensitivity of Sokolow–Lyon and Cornell voltage criteria for LVH. In their study, the sensitivity of Cornell voltage criterion was 22.5% for males and 28% for females, Rodrigues et al. reported a similar finding, our results go with Sergio et al. in which sensitivity of Cornell voltage criterion was higher for female [41, 42].

There are limitations for this study; the sample size is small, the duration of the study was short and finally, although we assessed risk factors at the time, we could not reliably measure how long the risk factors had been present before, as patients may not seek medical attention.

## CONCLUSION

This study found that the prevalence of left ventricular hypertrophy (LVH) was 30% among hypertensive population. Effort should be made for early detection and treatment of LVH since it carries bad prognosis. Left ventricular hypertrophy was more prevalent in female, especially eccentric type. Electrocardiography cannot be used as a substitute of Echo in detecting LVH, because their sensitivity is, unacceptably low.

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## Author Contributions

Amanj A. Khaznadar – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

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## Guarantor of Submission

The corresponding author is the guarantor of submission.

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None

## Conflict of Interest

Authors declare no conflict of interest.