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RESEARCH ARTICLE

LEFT VENTRICULAR MASS IN HYPERTENSION – CORRELATIVE STUDY OF
ELECTROCARDIOGRAPHY AND ECHOCARDIOGRAPHY

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ABSTRACT

Background: Left ventricular hypertrophy {LVH} has been repeatedly shown to be associated with a marked increase in cardiovascular risk. The ECG evidence of LVH is present only in 50% of patients with anatomic LVH. ECG may be entirely normal in around 15% patients with severe LVH. Echocardiography can show LVH in almost 100% of patients.

Objective: The purpose of this study is to determine the sensitivity of ECG in diagnosis of left ventricular hypertrophy by its correlation with echocardiography studies of left ventricular mass in hypertensive patients.

Materials and Methods: The study was carried out on 130 patients attending the hospital with systemic hypertension diagnosed by JNC VII criteria and managed at B.L.D.E A's Shri B.M Patil Medical College and Hospital. 12 lead ECG and Echo cardiograph examination for assessment of left ventricular function and mass was done using M mode and 2D echocardiography. Left ventricular mass was calculated in each case using the Devereux Formula. $LV\ Mass = 1.04 [(IVS (d) + LVID (D) + LVPWT (d))^3] - [LVID (d)]^3 - 13.6gms$ where 1.04 is the specific gravity of cardiac muscle. Comparison was done with a control group of 100 patients. The correlation of ECG data and echocardiograph findings in relation to LV mass was carried out in each case.

Observations: In all the patients in study group ECG evidence of LVH was calculated by Sokolow-Lyon criteria and Romhilt-Estes scoring systems. LVH by Sokolow-Lyon criteria was present in 29 patients (22.31%), and LVH was absent in 101 patients (77.69%), but echocardiograph showed LVH in all 130 patients. Observed LVH by Romhilt-Estes scorings system was present in 38 patients (29.23%) and absent in 92 patients (70.77%). But echo cardiograph showed LVH in all 130 patients. The mean left ventricular mass calculated was $179.07 \pm 36.62gms$ in males and $103.78 \pm 15.84gms$ in females in study group. Control group had $112.84 \pm 5.88gms$ in males and $73.36 \pm 9.41gms$ in females. There was significant increase in the left ventricular mass in study group when compared to control group. The sensitivity of Sokolow-Lyon was 22.30% and the sensitivity of Romhilt Estes point scoring system was 29.23%. Sensitivity of echo in detecting LVH in hypertensive patients was 100%.

Conclusion: It is concluded in our study that echocardiography is highly reliable and sensitive compared to electrocardiogram in the assessment of LVH in these patients.

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INTRODUCTION

A variety of cardiovascular disorders are characterized by left ventricular hypertrophy. Left ventricular hypertrophy is not only an important haemo-dynamic compensation for an over burdened heart but also an important independent parameter for predicting morbidity and mortality for various

cardiovascular events. Electrocardiogram, echocardiographic and radiographic studies have been found to be indicators of left ventricular hypertrophy and LV mass (Feignbaun *et al.*, 1968 and Troy *et al.*, 1971). Left ventricular hypertrophy has been repeatedly shown to be associated with marked increase in cardiovascular risk. The relative risk associated with 100gms increase in left ventricular mass was 2.1 while a 0.1 cm increase in left ventricular posterior wall thickness was associated with a seven-fold increase in the risk of mortality. Unfortunately conventional electrocardiograph criteria which

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are primarily aimed at recognizing the presence or absence of LV hypertrophy have a low sensitivity and limited utility (Murry *et al.*, 1972 and Popp *et al.*, 1973). The correlation of ECG patterns of LV hypertrophy with the anatomical findings offer the firm basis for an appraisal of accuracy of ECG criteria. The ECG evidence of LVH is present only in 50% of patients with anatomic LVH. ECG may be entirely normal in around 15% patients with severe LVH (Sokolow- Lyon, 1941). There is relationship between left ventricular mass and hypertension once the hypertension is diagnosed and treated. There was an assessment of left ventricular hypertrophy by electrocardiography which was correlated with left ventricular mass assessed by echocardiography. It was found that the echocardiograph parameters of left ventricular mass in hypertensive subjects correlated better when compared with electrocardiograph parameters of left ventricular hypertrophy in patients with hypertension (Scott, 1955). LV hypertrophy can be diagnosed by nuclear studies, echocardiography, and angiography. Echocardiograph measurement of LV mass has been shown to correlate closely with its measurements by angiography but has the advantage of being non-invasive and easily repeatable (Allenstain and Mori, 1960). Primary echocardiograph parameters of left ventricular hypertrophy are septal hypertrophy and LV posterior wall thickness. LV hypertrophy indicates that mass of left ventricle has increased. Therefore, from equations which permit one to calculate LV mass, a direct estimation of LV mass by echocardiograph is more helpful in determination of cardiac hypertrophy (Chou *et al.*, 1960). The purpose of this study is to determine the sensitivity of ECG in diagnosis of LV hypertrophy by its correlation with the echocardiographic studies of LV mass.

MATERIALS AND METHODS

In this study 130 patients with essential systemic hypertension having blood pressure level 140/90 mmHg and above and managed at SHRI B.M.PATIL MEDICAL COLLEGE AND HOSPITAL were selected. Left ventricular mass of 130 consecutive patients with hypertension was assessed who attended B.L.D.E A's SHRI B.M.PATIL MEDICAL COLLEGE, BIJAPUR from November 2007 to November 2008 and compared with 130 control subjects of age, sex and risk factors matched. A sample size of 130 was worked out at 95% level of confidence and with 5% margin of error and prevalence of 10% of hypertension⁴⁹ was used for calculating the desired sample size. ($Z \alpha = 1.96$, $d = 0.05$, $p = 0.10$, $n = 0.90$).

The formula used is,

$$n = \frac{(1.96)^2 (p) (1-p)}{d^2}$$

After taking a detailed history, clinical cardiovascular examination was carried out to rule valvular, congenital and ischemic heart diseases. The patient's resting blood pressure level was recorded in the right upper limb (after 15 minutes of rest). The recording was repeated at 15 minutes interval and the average of three readings was taken. Study design selected was case control study.

The statistical formulas used were,

1. Z list
2. X² list
3. Mean
4. Standard deviation
5. Correlation
6. Diagrammatic representations
7. Fischer's exact test (if necessary)

Inclusion Criteria

Patients having blood presser of 140/90 mmHg recorded in right upper limb after 15 minutes of rest. The recording was repeated at 15 minutes interval and the average of these readings was taken. Hypertension was diagnosed according to JNC VII criteria.

Exclusion Criteria

1. Patients with cardiomyopathy.
2. Patients with evidence of arrhythmias.
3. Patients with chronic obstructive lung diseases.
4. Patients with collagen vascular diseases which itself is capable of increasing thickness of myocardium.
5. Patients with aortic stenosis and aortic regurgitation.
6. Patients with well controlled hypertension on treatment.

All the 130 patients having essential hypertension were subjected to following investigation.

- | | |
|----------|------------|
| 1. Blood | 2. Urine |
| Hb % | Albumin |
| TC | Sugar |
| DC | Microscopy |
| ESR | |
3. Biochemical investigations
Random blood sugar
Blood urea
Serum creatinine to detect renal and metabolic causes
Lipid profile
 4. Chest x-ray PA view to detect cardiomegaly
 5. 12 lead electro cardiogram
 6. Echocardiography.

All these 130 patients were subjected to 12 lead electrocardiograms with paper speed of 25mm/second.

The ECGs were analyzed with respect to standardization, rate, rhythm, p wave, P.R. interval, Axis, QRS duration and ST-T changes. The voltage in precordial leads was analyzed according to the following criteria for detecting left ventricular hypertrophy.

- Sokolow-Lyon Criteria (Sokolow- Lyon, 1941):
S in V1 + R in V5 or R in V6 > 35mm.
- Each ECG was scored according of Romhilt- Estes point scoring system (Estes and Carter, 1964 and Romhilt and Estes, 1968)

1. R or S wave in any limb leads > 20mm
Or S wave in V1 or V2 > 20 mm
Or R wave in V5 or V6 > 30 mm.....3 points
2. Left ventricular strain
ST segment and T wave in opposite direction to QRS complex
With digitalis.....3 points
Without digitalis.....1 point
3. Left atrial enlargement – terminal negativity of P wave in V1 > 1mm in depth or > 0.04 seconds in duration.....3 points
4. Left axis deviation > -30 degree.....2 points
5. QRS duration > 0.09 seconds.....1 point
6. Ventricular activation time > 0.05 seconds.....1 point

TOTAL 13 POINTS
PROBABLE LVH = 4 POINTS
LVH = 5 POINTS

Echocardiographic examination for assessment of left ventricular function and mass was done. The pulse wave Doppler study of the mitral inflow tract was done in all cases. A detailed analysis of mitral valve spectral flow was carried out to detect associated early left ventricular diastolic dysfunction. Measurement of A.E. ratio was carried out.

The following left ventricular dimensions in the M-mode under guidance of left parasternal 2D long axis view just above the tip of the papillary muscle were measured in each case. On an average 3 observations were taken for each reading.

- Left ventricular internal diameter at end diastole (LVIDD).
- Interventricular septal thickness at end diastole (IVS-d).
- Left ventricular posterior wall thickness (LVP WT-d).

Besides these, the left ventricular functions like ejection fraction and cardiac output were estimated in each case. While measuring interventricular septal thickness, right and left septal endocardial echoes were excluded and so were posterior wall endocardial echoes while measuring posterior left ventricular wall thickness.

For left ventricular internal dimension and measuring both left septal endocardial echo and posterior wall endocardial echo were included. Left ventricular mass was calculated in each case using the Devereux Formula (Devereux and Reichek, 1977).

LV Mass=1.04 [(IVS (d)+ LVID (D)+ LVPWT (d))³] - [LVID (d)]³ - 13.6gms where 1.04 is the specific gravity of cardiac muscle.

The control group of the study consisted of 100 normal individuals with no evidence of any heart disease between the age group of 40 and 65 years with matching age, sex and risk factors. The correlation of ECG data and echo cardio graph findings in relation to LV mass was carried out in each case.

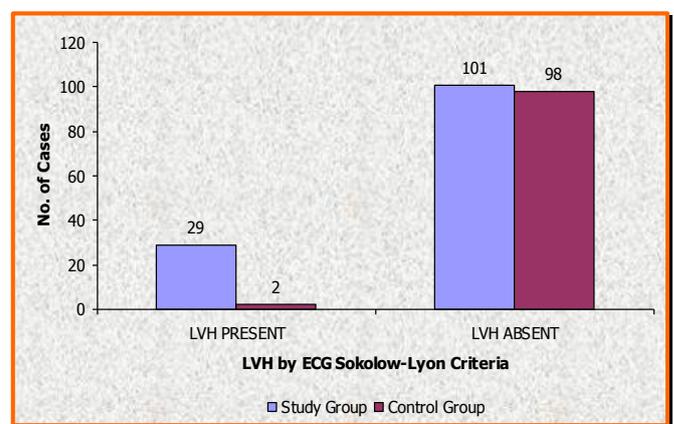
LV mass more than 131gms in men and more than 90gms in women were considered as abnormal (Levy *et al.*, 1987 and Trivedi *et al.*, 1991).

RESULTS AND DISCUSSION

In this study 130 patients with blood pressure value of 140 systolic and diastolic of 90mm Hg and above were selected who attended B.L.D.E A's SHRI B.M.PATIL MEDICAL COLLEGE, BIJAPUR from November 2007 to November 2008 and compared with 100 control subjects of age, sex and risk factors matched.

Table 1. Lvh by ECG Sokolow-Lyon Criteria

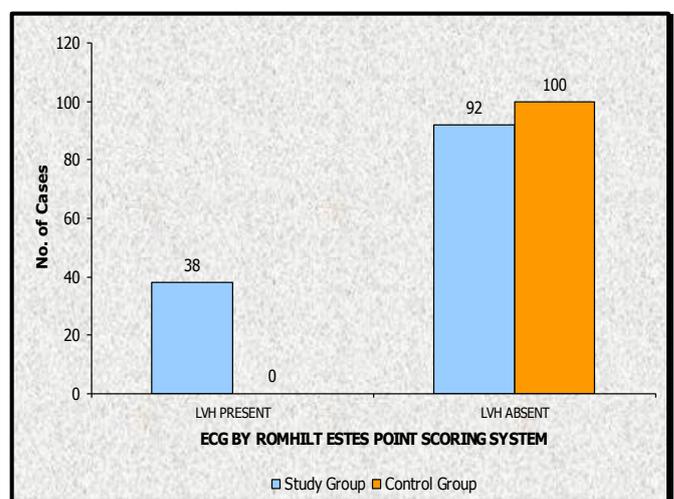
	STUDY GROUP	CONTROL GROUP
LVH PRESENT	29	02
LVH ABSENT	101	98



It is evident from the above table that LVH was evident in 29 patients that is in 22.31% of patients. LVH was not present in 101 patients that is 77.69%. Control group had 2 patients showing LVH and 98 showing no evidence of LVH.

Table 2. ECG by Romhilt Estes Point Scoring System

	STUDY GROUP	CONTROL GROUP
LVH PRESENT	38	0
LVH ABSENT	92	100



It is evident that LVH was present in 38 patients (29.23%). LVH was absent in 92 patients (70.77%). Control group had no evidence of LVH.

Table 3. Relationship of ECG LVH By Sokolow-Lyon Criteria To Echocardiograph LVH

	Study	Group	Control	Group
ECG by Sokolow Lyon Criteria	LVH Present	LVH Absent	LVH Present	LVH Absent
	29	101	02	98
ECHO Cardiograph Percentage	130	00	04	96
	ECG- 22.30%			ECHO- 100%

From the above Table 3 it is evident that LVH by ECG criteria was present in 29 patients (22.31%), and LVH was absent in 101 patients (77.69%), but echo cardiograph showed LVH in all 130 patients. Control group had LVH by ECG in 2 patients and by echocardiograph in 4 patients. 98 patients did not have evidence of LVH in ECG.

Table 4. Relationship of ECG LVH By Romhilt Estes Scoring System to ECHO Cardiograph LVH

	Study Group		Control Group	
	LVH Present	LVH Absent	LVH Present	LVH Absent
ECG by Romhilt Estes Scoring System	38	92	00	00
Echocardiograph	130	00	00	00
Percentage	ECG- 29.23%		ECHO- 100%	

From Table 4 we observed LVH by Romhilt-Estes scorings system was present in 38 patients (29.23%) and absent in 92 patients (70.77%). But echo cardiograph showed LVH in all 130 patients.

Table 5. Sensitivity and Specificity of ECG Criteria

	Sokolow-Lyon Criteria	Romhilt-Estes Scoring System
Sensitivity	22.30%	29.23%
Specificity	100%	100%
Predictive value for positive test	100%	100%
Predictive value for negative test	55.38%	41.54%
Percentage of false positive	0%	0%
Percentage of false negative	77.70%	70.77%

From table 5 it is evident that LVH by Sokolow Lyon criteria showed sensitivity of 22.30% compared to Romhilt Estes Showing 29.23%. Specificity and predictive value for positive test was present in 100% patients, in Sokolow-Lyon criteria and Romhilt Estes, percentage of false positive was 0% in both systems, but percentage of false negative was 77.70% in Sokolow Lyon criteria and 70.77% in Romhilt Estes scoring system. Combined criteria showed sensitivity of 25.76%.

Table 6. Comparison of LV Mass in Study and Control Group

	Male		Female		Total	
	NO	Mean±SD	No	Mean±SD	No	Mean±SD
Study Group	95	179.07 ±36.62	35	103.78 ±15.14	130	158.79 ±32.27
Control Group	76	112.84 ±5.88	25	73.36 ±9.41	100	103.36 ±6.89

All 130 patients were detected to have increased left ventricular mass by echo cardiograph.

The mean left ventricular mass was 179.07±36.62gms in males and 103.78±15.14gms in females. All the 130 patients were detected to have left ventricular diastolic dysfunction on echocardiograph study. Comparison of both study and control group was done using Z test (Park, 2005).

Comparing study group and control group in LV mass, Z = 19.11 p < 0.01 HIGHLY SIGNIFICANT.

Comparing males and females of study group, Z = 16.73 p < 0.01 HIGHLY SIGNIFICANT.

Comparing males of study and control group, Z = 17.45 p < 0.01 HIGHLY SIGNIFICANT.

Comparing females of study and control group, Z = 9.5 p < 0.01 HIGHLY SIGNIFICANT.

Comparing males and females of control group, Z = 19.35 p < 0.01 HIGHLY SIGNIFICANT.

DISCUSSION

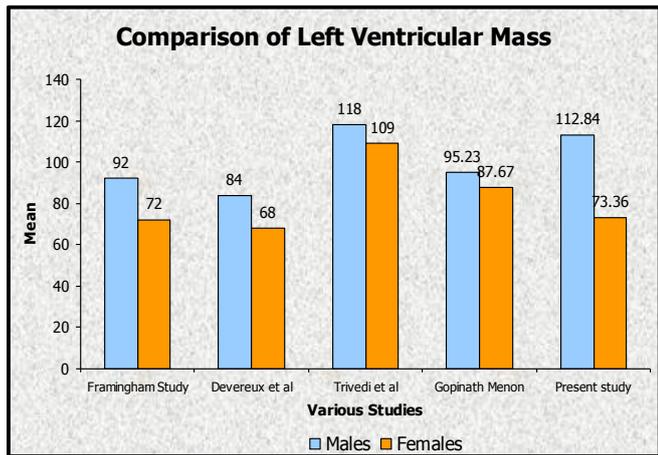
Echo-cardiograph criteria for left ventricular hypertrophy has been shown to have excellent sensitivity, specificity and accuracy when compared with post mortem left ventricular mass and its reliability has also been confirmed by angiographic studies (Feignbaun and popp, 1968; Troy *et al.*, 1971; Murry *et al.*, 1972 and Popp *et al.*, 1973). The population studied in this study permitted the assessment of Sokolow Lyon criteria and Romhilt-Estes scoring criteria in a clearly defined clinical settings. Both electro-cardiograph criteria appeared to have a low sensitivity and specificity (Sokolow-Lyon, 1941 and Scott, 1955). After taking ECG the left ventricular hypertrophy was calculated by Sokolow-Lyon criteria and Romhilt-Estes scoring systems. We found left ventricular hypertrophy by Sokolow Lyon criteria sensitivity of 22.30% and specificity of 100% and by Romhilt-Estes scoring sensitivity of 29.23% and specificity of 100% (Sokolow- Lyon, 1941 and Scott, 1955). In the original study of Sokolow-Lyon *et al.* (1941) sensitivity was 22%. (Devereux and Reichek, 1977) found sensitivity of 60% (Devereux and Reichek, 1977). Nathaniel (Devereux and Reichek, 1977) found LVH by Romhilt-Estes criteria a sensitivity 50% and by Sokolow Lyon criteria sensitivity 20% both had specificity of 95%. In Estes original study sensitivity was 42%, specificity 96%.

In the present study echocardiograph parameters of left ventricular hypertrophy could be detected in 130 out of 130 patients while both the electrocardiographic criteria taken together could detect only in 67 patients with sensitivity of 25.76%. Both the Sokolow-Lyon and Romhilt-Estes scoring criterion failed to show any correlation with left ventricular mass as both these criteria were insensitive in several patients with significant increases in left ventricular mass. In this study it was found that mean left ventricular mass was 179.07±36.62gms in males and 103.78±15.14gms in females. The relationship between clinical measurement of blood pressure and left ventricular hypertrophy in systemic hypertension appears to be weak in most studies. However the

Framingham data reported by Levy *et al.* (1987) showed modest but statistically significant correlation between systemic arterial blood pressure and left ventricular mass.

Left ventricular Mass in Grams in Different Studies of Normal Population

	Males	Females
Framingham Study	92+19.5	72+14
Devereux <i>et al</i>	84+24	68+20.5
Trivedi <i>et al</i>	118	109
Gopinath Menon	95.23	87.67
Present study	112.84±5.88	73.36±9.41



In the control group which had 100 normal individuals (76 males and 24 females). The mean left ventricular mass in males was 112.84±5.88gms and females 73.36±9.41gms. The corresponding values obtained by Devereux *et al*^{20, 39, 48} in their study were 84.24 gms for men and 68±20.5 gms in females (Devereux and Reichek, 1977). The Framingham study showed 92+19.5 gms in males and 72+14gms in females (Levy *et al.*, 1987). In Trivedi *et al.* (1991) study showed mean left ventricular mass in males 118gms and in females 109gms. Corresponding values obtained by Gopinath Menon *et al* in Indian study was 95.23gms in males (Gopal *et al.*, 1997). Our study suggests that in hypertensive patients the reliability of electrocardiographic criteria is poor and the reliability of echocardiographic criteria is better.

Conclusion

This study suggests that echo-cardiography is far superior tool in the detection of LVH in hypertensive patients compared to electro-cardiogram.

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