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## SENSITIVITY AND SPECIFICITY OF DIFFERENT ELECTROCARDIOGRAPHIC CRITERIA FOR LEFT VENTRICULAR HYPERTROPHY WITH REFERENCE TO ECHOCARDIOGRAPHY

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### ABSTRACT

**OBJECT:** To determine the sensitivity and specificity of different electrocardiographic criteria for left ventricular hypertrophy with reference to echocardiography.

**DESIGN:** Descriptive study.

**SETTING:** Medical Unit III, Jinnah Post-graduate Medical Centre Karachi.

**DURATION:** June 1998- February 1999.

**METHODS:** 50 patients with proved echocardiographic left ventricular hypertrophy (LVH) and 25 normal persons without echocardiographic LVH were included in the study. All patients and healthy person were examined clinically and their ECGs were taken on the same day. Echo LVH was defined if Left Ventricular Mass Index exceeded  $118 \text{ g/m}^2$  in males and  $104 \text{ g/m}^2$  in females. Data was preserved and now it is analyzed for Electrocardiographic LVH in view of (i) Gubner Ungerleider criterion (ii) Sokolow Lyon  $R_{aVL}$  criterion (iii) Sokolow Lyon  $Sv_1 + Rv_{5/6}$  criterion (iv) Romhilt Estes Score system (v) cornell voltage criterion and (vi) cornell product index. Sensitivity and specificity was calculated by standard formula and P value derived by chi square test.

**RESULTS:** 50 patients, 21(42%) were male and 29 (58%) were females. 25 healthy persons without LVH, 12 (48%) were males and 13 (52%) were females. Gubner Ungerleider criterion was 29% sensitive in males, 10% sensitive in females and 18% in all patients. Sokolow Lyon  $R_{aVL}$  criterion was 24% sensitive in males, 10% in females and 16% sensitive in all patients; with 96% specificity. Sokolow Lyon Precordial criterion was having sensitivity of 48% in males, 31% in females and 38% in all patients; while 100% specific. Romhilt Estes point score system was achieving sensitivity of 67% in male population, 31% in female population and 46% in all patients. It was 100% specific. Cornell voltage criterion was having sensitivity of 48% as over-all, 48% in males and also 48% in females. It was 96% specific. Cornell product index was the highest sensitive by achieving 57% in males, 62% in females and 60% in all patients.

**CONCLUSION:** Electrocardiography though less sensitive than echocardiography, can perform better in certain groups and with improved criteria. Cornell product criterion has the highest sensitivity.

**KEY WORDS:** Left – Ventricular – hypertrophy – Electrocardiography – Echocardiography – Sensitivity – Specificity – Criteria – Gubner Ungerleider – Sokolow Lyon – Romhilt Estes – Cornell.

### INTRODUCTION

Normal human heart weighs from 280-340 (average 300) grams in males and from 230-280 (average 250) grams in females during adult life<sup>1</sup>, out of which left ventricle is 200 grams. In abnormal condition heart may get enlarged resulting in hypertrophy. Left ventricular hypertrophy (LVH) is manifestation of reserve mechanism of the heart resulting form adaptation to acute or chronic, pressure/ volume overload to left ventricle.<sup>2</sup> LVH may be useful in early stage but is deleterious as the time passes and discrepancy between muscle mass and nutritional supply arises.<sup>2,3</sup> Hypertension is more frequent cause of LVH<sup>4</sup> as compared to other causes e.g. Mitral regurgitation, Aortic Stenosis or regurgitation, Cardiomyopathies etc. Hypertension is more common in blacks.<sup>5</sup> Hypertension is closely related to obesity and both are associated with coronary artery disease (CAD) and cardiovascular death.<sup>4,6,7</sup> So LVH is a strong predictor of cardiovascular morbidity and mortality resulting from hypertension<sup>8</sup>,

aortic stenosis / regurgitation<sup>9</sup>, cardiomyopathy with or without CAD.<sup>4,10</sup> Therefore detection of LVH is very important step to prevent dangerous consequences. LVH can be detected by electrocardiography, echocardiography, CT scan and MRI. Electrocardiography is cheap, easily available, easy to perform & interpret. It is being used since 1914 for LVH despite low sensitivity i.e 20-60% for different criteria but highly specific i.e >95%.<sup>11,12</sup> Other techniques require high cost, expertise & technique. So ECG is still recommended for detection of LVH in a population of high prevalence.<sup>13,14</sup> Electrocardiographic LVH is associated with 3 fold increased risk of CAD.<sup>7,15</sup> Various commonly used criteria are:

- i. Gubner Ungerleider criteria.<sup>16</sup>
- ii. Sokolow Lyon  $R_{av1} = 11$  mm.<sup>17</sup>
- iii. Sokolow Lyon Precordial criterion  $S_{V1} + R_{V5/6} = 35$  mm<sup>17</sup>
- iv. Romhilt Estes point score =5 points.<sup>18</sup>
- v. Cornell voltage criterion  $R_{avL} + S_{V3} = 20$  in females and = 28 in males.<sup>19</sup>
- vi. Cornell product index.<sup>20</sup>

So this study is intended to determine the sensitivity and specificity of above mentioned electrocardiographic criteria for LVH in our population.

#### MATERIAL AND METHODS

This descriptive study was conducted at Medical Unit-III of Jinnah Postgraduate Medical Centre Karachi from June 1998 to February 1999. Where ECG machine and echocardiography machine are available.

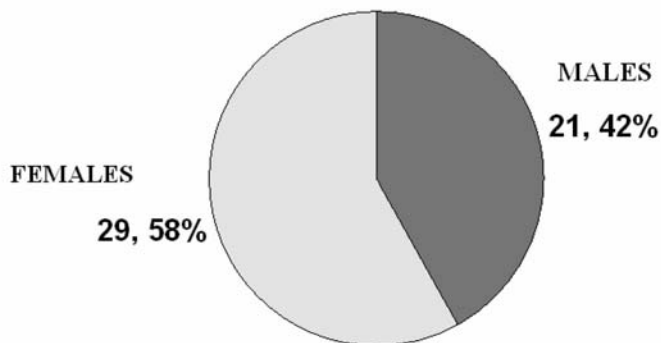
**Inclusion criteria:** All patients, who came for echocardiography for various reasons and proved to have left ventricular hypertrophy were included in study.

**Exclusion criteria:** Patients with LVH but having the following problems were excluded from the study.

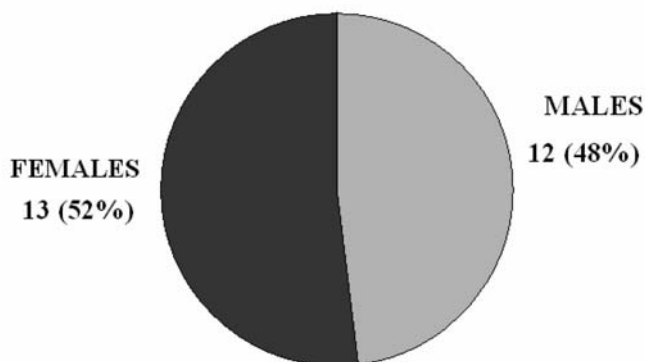
- I. Right bundle branch block.
- II. Left bundle branch block.
- III. Pre-excitation syndromes.
- IV. Atrial fibrillation.
- V. Myocardial infraction.
- VI. Asymmetric hypertrophic cardiomyopathy.
- VII. Pericarditis or pericardial effusion
- VIII. Chronic obstruction pulmonary disease.
- IX. Massive pleural effusion
- X. Clinical hypothyroidism.
- XI. Left ventricular aneurysm
- XII. Female patients with mastectomy.

**Control cases:** 25 healthy subjects matched with age, sex and built from medical &

**FIGURE:1**  
**GENDER DISTRIBUTION OF PATIENTS**



**FIGURE:2**  
**GENDER DISTRIBUTION OF CONTROL SUBJECTS**



**TABLE I:**  
**SENSITIVITY IN ALL PATIENTS**  
(N 50)

S#	Name of Criteria	No. of patients	Sensitivity	Confidence Interval	P value
1	Gubner Ungerleider	9	18%	9-32%	.001
2	Sokolow lyon $R_{av1}$	8	16%	8-30%	.001
3	Sokolow lyon $S_{V1} + R_{V5/6}$	19	18%	25-53%	<.001
4	Romhilt Estes Score	23	46%	32-61%	<.001
5	Cornell voltage	24	48%	34-62%	<.001
6	Cornell product index	30	60%	45-75%	<.001

**TABLE II:**  
**SENSITIVITY IN MALE PATIENTS**  
(N 21)

S#	Name of Criteria	No. of patients	Sensitivity	Confidence Interval
1	Gubner Ungerleider	6	29%	12-52%
2	Sokolow lyon $R_{av1}$	5	24%	12-52%
3	Sokolow lyon $S_{V1} + R_{V5/6}$	10	48%	26-70%
4	Romhilt Estes Score>5	14	67%	43-85%
5	Cornell voltage	10	48%	26-70%
6	Cornell product index	12	57%	37-80%

paramedical staff of JPMC and from persons referred for echocardiography but not having LVH or any other apparent clinical disorders were selected as control group.

**Echocardiography:** It was performed by an experienced cardiologist on Toshiba model SSA 270 A and patients were examined by 2.5 MHz probe in a partial Left lateral decubitus position according to recommendation of American society of Echocardiography. Left ventricular mass was calculated by modified Penn Cube formula and then indexed to body surface area. LVH was defined if left ventricular mass

**TABLE III :  
SENSITIVITY IN FEMALE PATIENTS  
(N 29)**

S#	Name of Criteria	No. of patients	Sensitivity	Confidence Interval
1	Gubner Ungerleider	3	10%	3-29%
2	Sokolow lyon $R_{avL}$	3	10%	3-29%
3	Sokolow lyon			
	$Sv_1 + Rv_{5/6}$	9	31%	16-51%
4	Romhilt Estes Score >5	9	31%	16-51%
5	Cornell voltage	14	48%	30-67%
6	Cornell product index	18	62%	42-85%

**Table IV:  
SPECIFICITY OF ECG CRITERIA IN MALES AND  
FEMALES.**

S#	Name of Criteria	Male (n 12)			Female (n 13)		
		No. of pts:	Specificity	Confidence Interval	No. of pts:	Specificity	Confidence Interval
1	Gubner Ungerleider	0	100	70-100	1	92	62-99.6
2	Sokolow lyon $R_{avL}$	0	100	70-100	0	100	72-100
3	Sokolow lyon						
	$Sv_1 + Rv_{5/6}$	0	100	70-100	0	100	72-100
4	Romhilt Estes Score	0	100	70-100	0	100	72-100
5	Cornell voltage	1	92	60-99.6	0	100	72-100
6	Cornell product index	1	92	60-99.6	0	100	72-100

index (LVMI) exceeded 118 g/m<sup>2</sup> in males and 104 g/m<sup>2</sup> in females.

**Electrocardiography:** It was performed on 6 channel automatic computerized Siemens cicard 440 machine with paper speed of 25 mm/sec and amplitude standard of 1 mv = 10 mm.

The ECGs were taken on the same day of echocardiographic and clinical examination. ECGs were examined for the following 6 criteria for LVH.

i. Gubner Ungerleider criteria<sup>16</sup>  $R_1 + S_{III} = 25mm$ .

ii. Sokolow Lyon  $R_{avL} = 11 mm$ .<sup>17</sup>

iii. Sokolow Lyon Precordial criterion  $S_{V_1} + R_{V_5/6} = 35 mm$ .<sup>17</sup>

iv. Romhilt Estes point score >5 points.<sup>18</sup>

Largest S/R wave in limb leads = 20mm  
Largest S wave in  $V_1 / V_2$  or largest R wave in  $V_5 / V_6 = 30mm$  3 points.

ST.T changes (typical strain pattern) 1 point.

Left atrial enlargement 3 points.

Left axis deviation = 30° 2 points.

QRS duration = 0.09 sec 1 point.

Intrinsicoid deflection = 0.05 sec 1 point.

v. Cornell voltage criterion  $R_{avL} + S_{V_3} = 20$  in females and = 28 in males.<sup>19</sup>

**Table V:  
SPECIFICITY OF ECG CRITERIA  
(n 25)**

S#	Name of Criteria	All No. of pts:	Specificity	Confidence Interval
1	Gubner Ungerleider	1	96	78-99.8
2	Sokolow lyon $R_{avL}$	0	100	83-100
3	Sokolow lyon			
	$Sv_1 + Rv_{5/6}$	0	100	83-100
4	Romhilt Estes Score	0	100	83-100
5	Cornell voltage	1	96	78-99.8
6	Cornell product index	1	96	78-99.8

vi. Cornell product index.<sup>20</sup>

In males  $(R_{avL} + S_{V_3}) \times QRS_{(msec)} > 2440$ .

In females  $(R_{avL} + S_{V_3} + 8) \times QRS_{(msec)} > 2440$ .

Sensitivity & specificity were determined by standard formula and compared to echocardiography by chi square test.

## RESULTS

62 Patients with echocardiographic criteria were initially included; but 12 patients were

excluded due to above mentioned exclusion criteria. So, 50 patients, 21 male (42%) and 29 female (58%) were included in the study. Their ages were between 17 and 75 years (mean age  $41.26 \pm 15.94$ ) and body surface area ranged between 1.2 and 1.9 m<sup>2</sup> (mean  $1.57 \pm 0.15$ ) 28 patients were hypertensive (56%), 12 patients (24%) with aortic/mitral regurgitation and 10 patients (20%) were having cardiomyopathy.

Their left ventricular mass index was from 107 to 349 g/m<sup>2</sup> mean  $178.14 \pm 56.53 g/m^2$

in males 122-349 (mean  $200.14 \pm 60.32$ ) with in females 107-307 (mean  $162.2 \pm 49.81$ ) g/m<sup>2</sup>.

Out of 25 persons without (LVH), 12(48%) were male and 13(52%) were females.

Their ages were between 20 and 63 year (mean  $38.52 \pm 12.7$ ).

Their LVMI was below 118 g/m<sup>2</sup> in males and 104 g/m<sup>2</sup> in females.

Sensitivity and specificity of all 6 ECG criteria are presented in Table I, (all patients), Table II (male patients), Table III (female patients). Specificity is presented in Table IV and Table V.

## DISCUSSION

Left ventricular hypertrophy is an important and strong predictor of cardiovascular morbidity. Hypertension is common cause for it. LVH once established is associated with increased morbidity and mortality. ECG has been helping since 1914 with varying sensitivity but high specificity. Gubner Ungerleider criterion presented in 1943, was 50% sensitive in original study but not confirmed yet with such high sensitivity; was 18% sensitive in our study with 96% specificity. It was more sensitive in male patients (29%) as compared to females 10%. Sokolow Lyon RaVL Criterion presented in 1949 was 16% sensitive in original and other national and international studies<sup>21,22,23,24,25,26,27</sup> maintaining the near 100% specificity. This criterion in our study was 16% sensitive in males 29% and in females 10% while specificity remained at 100% ( $P < 0.001$ ).

Sokolow Lyon  $Sv_1 + Rv_5/6$  criterion performed well by achieving sensitivity of 38% in all patients ( $P < .001$ ), 48% in males and 31% in females, maintaining the specificity of 100%. It was 32% sensitive in original study and 100% specific. Other international studies also confirm our findings.<sup>21,22,23,24,25,26,27</sup>

Romhilt Estes point score system was 46% sensitive and 100% specific in our study ( $<.001$ ) with higher sensitivity in males 67% while in females 31%. Original study was 54% sensitive and 97% specific; hence apart from male dominance, our results correlate well with national<sup>21,25</sup> and international data.<sup>22,23,24</sup>

Cornell voltage criterion was equally sensitive in males and females achieving 48% in each sex and also over all 48% sensitivity ( $P <.001$ ) but 96% specific.

This may be its sex specific values. In their original study it was 41% sensitive and 95% specific. Saulal Siddiqui et al have proved it. 50% sensitive and 93% specific.<sup>25</sup> Cornell product index has performed the best of all criteria by achieving 60%

sensitivity ( $p < .001$ ) in all the patients with 96% specificity, while 62% sensitivity in female population and 57% sensitive in male population. Such results have been achieved in other studies.<sup>28</sup>

Therefore it is evidence from this study that Cornell voltage criteria performs better than any other criteria for detecting LVH.

## CONCLUSION

ECG though less sensitive than echocardiography for detecting LVH but highly specific; can perform better in certain groups. Romhilt Estes Point Score system, Sokolow Lyon precordial voltage criterion are nearly equally sensitive and specific but Cornell product Criterion is enjoying highest sensitivity; but still efforts are needed to optimize the sensitivity of a common tool i.e, Electrocardiography to detect LVH more effectively.

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