

## Relevance of the electrocardiogram in the diagnosis of left ventricular hypertrophy of patients on hemodialysis

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### ARTICLE INFORMATION

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### Competing interests

The authors declare no competing interests

### Acronyms

**CKD:** chronic kidney disease

**ECG:** electrocardiogram

**HBP:** high blood pressure

**LVH:** left ventricular hypertrophy

**LVM:** left ventricular mass

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### ABSTRACT

**Introduction:** Left ventricular hypertrophy (LVH) is the most frequent structural cardiac alteration in patients with chronic kidney disease on hemodialysis. The electrocardiogram is the initial diagnostic resource used in the dialysis units for identification.

**Objective:** To evaluate the usefulness of the electrocardiogram in the diagnosis of LVH in patients with chronic kidney disease on hemodialysis.

**Method:** A total of 80 patients on hemodialysis were studied. The sensitivity, specificity and predictive values of seven electrocardiographic criteria of LVH were analyzed and correlated with the echocardiographic findings.

**Results:** LVH was identified by the electrocardiogram in 33 hemodialysis patients (41% of cases). The electrocardiogram showed 50% of sensitivity, 82% of specificity and 87% of positive predictive value in the diagnosis of LVH. The Sokolow-Lyon voltage was the most useful criterion for the diagnosis of LVH, due to its higher sensitivity (43%), high specificity (86%) and positive predictive value (89%). The pattern of systolic overload of the left ventricular prevailed among the diagnostic criteria of the Romhilt-Estes score. The Sokolow-Lyon voltage was the most useful criterion for detecting concentric forms of hypertrophy, whereas the voltage criterion of the R wave in aVL was the most useful for detecting severe forms.

**Conclusions:** The electrocardiogram is a useful diagnostic tool to certify the existence of LVH in patients with chronic kidney disease on hemodialysis. Its diagnostic utility is greater when it comes to identify concentric and severe forms of LVH.

**Key words:** Left ventricular hypertrophy, Electrocardiography, Chronic kidney disease, Hemodialysis

### *Valor del electrocardiograma en el diagnóstico de hipertrofia ventricular izquierda de pacientes en hemodiálisis*

### RESUMEN

**Introducción:** La hipertrofia ventricular izquierda (HVI) es la alteración estructural cardíaca más frecuente en pacientes con enfermedad renal crónica en hemodiálisis. El electrocardiograma es el medio diagnóstico inicial empleado en las unidades de diálisis para su identificación.

**Objetivo:** Evaluar la utilidad del electrocardiograma en el diagnóstico de HVI en

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*pacientes con enfermedad renal crónica en hemodiálisis.*

**Método:** Se estudiaron 80 pacientes en hemodiálisis. Se analizó la sensibilidad, especificidad y valores predictivos de siete criterios electrocardiográficos de HVI y se correlacionaron con los hallazgos ecocardiográficos.

**Resultados:** Se identificó HVI mediante el electrocardiograma en 33 pacientes hemodializados (41% de los casos). El electrocardiograma mostró 50% de sensibilidad, 82% de especificidad y 87% de valor predictivo positivo en el diagnóstico de HVI. El voltaje de Sokolow-Lyon fue el criterio más útil para el diagnóstico de HVI por su mayor sensibilidad (43%), alta especificidad (86%) y valor predictivo positivo (89%). El patrón de sobrecarga sistólica del ventrículo izquierdo predominó entre los criterios diagnósticos de la puntuación de Romhilt-Estes. El voltaje de Sokolow-Lyon fue el criterio más útil para detectar formas concéntricas de hipertrofia mientras que el criterio de voltaje de R en aVL resultó el más útil para detectar formas graves.

**Conclusiones:** El electrocardiograma es un medio diagnóstico útil para certificar la existencia de HVI en pacientes con enfermedad renal crónica en hemodiálisis. Su utilidad diagnóstica es mayor para identificar formas concéntricas y graves de HVI.

**Palabras clave:** Hipertrofia ventricular izquierda, Electrocardiografía, Enfermedad renal crónica, Hemodiálisis

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## INTRODUCTION

Patients with chronic kidney disease (CKD) on hemodialysis frequently show a very high mortality rate of cardiac origin<sup>1</sup>.

It is known, since 1836<sup>2</sup>, that ventricular abnormalities are highly prevalent in patients with CKD and the left ventricular hypertrophy (LVH) has been identified as the most frequent structural cardiovascular manifestation in this population<sup>3</sup>. In chronic renal patients, LVH increases as the glomerular filtration rate decreases and it is higher in patients undergoing dialysis treatment, hence, this anomaly is usually present in more than 70%<sup>4,5</sup> of patients who enter hemodialysis and its existence has been linked to the development of ventricular arrhythmias and increased risk of cardiac ischemia.

Different means have been used in the diagnosis of LVH, which are: the resting electrocardiogram (ECG), the echocardiogram, the computerized axial tomography and the magnetic resonance. Different degrees of sensitivity and specificity<sup>6</sup> have been attributed to these studies, but undoubtedly, from all these diagnostic means, the most used for its convenience is the ECG, since it is less expensive, bloodless and easier to perform<sup>7</sup>. The ECG also provides information that cannot be obtained through other techniques. Specifically, the analysis of ST segment changes in LVH (left ventricular overload pattern) warns of its prognostic utility; this fact has

been well recognized and widely studied in the general population. Diagnosing LVH through ECG is based on different criteria purely of voltage, as the Sokolow-Lyon, the R wave in aVL, the Cornell voltages and the Gubner criterion. Other criteria include the combination of QRS duration and the voltage, as the products of Sokolow-Lyon and Cornell, and other combined criteria (scoring systems) as the Romhilt-Estes index<sup>8,9</sup>.

The frequency of LVH found by the ECG varies in relation to the different electrocardiographic criteria used for its identification and it also depends on the characteristics of the population under study.

Some research state wide variations in the prevalence of LVH when noticing that the ECG can identify only 5.3% of patients with CKD<sup>10</sup>, while others estimate that the ECG may show LVH in 17.8% of cases<sup>11</sup>, and up to more than 20%<sup>8</sup> of patients with CKD when using the different criteria.

Patients with CKD on hemodialysis are usually patients with high blood pressure (HBP) of long evolution, generally with the combination of poor muscle mass and tendency to be thin. It is well established that obesity attenuates the QRS voltage amplitude in the precordial leads by interposition of the tissue, which increases the distance between the electrodes and the left ventricular. Therefore, given the characteristics of the population under study, it is expected that the electrocardiographic analysis of LVH on dialysis patients is more useful than for the general population.

The usefulness of the ECG in identifying LVH in patients on hemodialysis has been, however, the subject of few studies. In a search conducted in the MEDLINE database, only four international papers were found, referring to the diagnostic utility of the different electrocardiographic criteria used in the identification of LVH on hemodialysis patients<sup>12-15</sup>.

Taking into account the importance of the topic and the scarcity of national and international studies, this research was designed with the aim of evaluating the usefulness of the ECG for the diagnosis of LVH in this population, through the analysis of the sensitivity, specificity and predictive values of the different electrocardiographic criteria.

## METHOD

The population under study consisted of 80 patients affected by terminal CKD from three hemodialysis units in Havana, aged over 20 years and stay for more than a year in treatment of chronic or regular hemodialysis, three times a week, through arteriovenous fistula as vascular access pathway. The study was carried out from April 2012 to April 2013.

### Research design

In the interest of evaluating the usefulness of ECG in the LVH identification, a descriptive evaluation of diagnostic tools that would equally estimate the sensitivity, specificity and positive and negative predictive value was designed. For this purpose, an ECG (test to be evaluated) and an echocardiogram (reference test) were performed to the entire selected population.

### Procedures and techniques

From each patient was collected, in the dialysis unit, information regarding age, sex, post-dialysis weight, height, time on dialysis, existence of a history of HBP, diabetes mellitus, chronic ischemic heart disease, peripheral arterial disease, and cerebrovascular disease. Facts about smoking, cause of renal failure and the use of antiarrhythmic, antischemic and specific antihypertensive drugs were collected.

The patients included in the study were evaluated during the first dialysis procedure of the week. Each patient underwent a thorough physical examination, a conventional 12-lead electrocardiogram

(post-dialysis) and an echocardiographic study (post-dialysis).

### Collection and analysis of electrocardiographic data

The instrument used to perform the ECG was the Cardiocid IIB, a 12-lead electrocardiographic system manufactured by the *Instituto Central de Investigación Digital (ICID)* and marketed by *Combiomed*.

The technique used was that recommended by the Electrocardiography and Arrhythmia Committee of the American Heart Association<sup>16</sup>. To perform the ECG, the speed of the recording was 25mm/s and the calibration was adjusted to 1 mV/cm. The ECGs were analyzed by two observers, specialists in Internal Medicine. None of them knew the results of the echocardiogram (gold test) of the subjects under research.

The data obtained by the electrocardiography were: QRS axis; voltage and duration of P in DII and V1; S and R voltages in limb and precordial leads; QRS duration; displacement of ST and T; and the presence of branch blocks. The measurements were made manually. The analysis of data obtained by the electrocardiography focused on the diagnostic value of this mean and the different electrocardiographic criteria in identifying ventricular hypertrophy according to the recommendations of the American Heart Association<sup>16,17</sup>.

Seven criteria were used to define LVH, which were:

- 1) Romhilt-Estes score: Voltage of R or S  $\geq 20$  mm or S in V<sub>1</sub> (V<sub>2</sub>)  $\geq 30$  mm or R V<sub>5-6</sub>  $\geq 30$  mm (three points); ST depression due to left ventricular systolic overload in V<sub>5</sub>o V<sub>6</sub> (three points); left atrial growth in V<sub>1</sub> (three points); QRS electric axis greater than  $\geq 30$  degrees (two points); QRS duration  $\geq 0.09$  s in V<sub>5</sub>o V<sub>6</sub> (point) or intrinsicoid deflection  $\geq 0.05$  second s in V<sub>5</sub>o V<sub>6</sub> (a point). Using this score, the LVH was diagnosed when the sum of the points was  $\geq 5$ .
- 2) Sokolow-Lyon voltage: SV<sub>1</sub> + RV<sub>5</sub>o V<sub>6</sub>  $\geq 35$  mm.
- 3) Sokolow-Lyon product: SV<sub>1</sub> + RV<sub>5</sub> o V<sub>6</sub> for the QRS duration  $\geq 3000$  mm/ms in women and  $\geq 4000$  mm/ms in men.
- 4) Cornell voltage: R aVL+ SV<sub>3</sub>  $\geq 20$  mm in women and  $\geq 28$  mm in men.
- 5) Cornell product: SV<sub>1</sub> + RV<sub>5</sub> o V<sub>6</sub> QRS duration  $\geq 2440$  mm/ms, plus 6 mm in women.
- 6) Gubner criterion: RD<sub>1</sub> + SD<sub>III</sub>  $> 25$  mm.
- 7) R aVL voltage: R aVL  $> 11$  mm.

### Collection and analysis of echocardiographic data

The echocardiogram, post-dialysis, was performed on the 80 subjects who made up the studied population. The assessment of this diagnostic study was performed in each hemodialysis service by a second degree specialist in Cardiology. The technique used was that recommended by the American Society of Echocardiography<sup>18</sup>. The instruments used in the performance of the echocardiogram in the health centers where the research was carried out were the Aloka Alpha 5 Pro Sound and the equipment Philips EPIQ 7. The experts who conducted did not know the result of the ECG of the individuals under study.

The analysis of the data obtained by the echocardiogram focused on the assessment and diagnosis of LVH according to the aforementioned recommendations<sup>18</sup>. The variables obtained were: thickness of the interventricular septum (IVS) and the left ventricular posterior wall (LVPW), left ventricular diastolic diameter (LVDD), left ventricular ejection fraction (LVEF), diastolic dysfunction, left ventricular mass (LVM), left ventricular mass index and the wall's relative thickness.

For the LVH analysis by echocardiography, the LVM was calculated by the mathematical formula<sup>19,20</sup>: **LVM in grams = 0.8(1.04[LVDD+LVPW+IVS]<sup>3</sup> - LVDD<sup>3</sup>) + 0.6**

The normal reference values for LVM were adjusted according to sex, men of 88-224 grams and women of 67-162 grams.

The calculation of the LVM was normalized by the body surface, and the left ventricular mass index was determined. The LVH was considered when this was greater than 115 g/m<sup>2</sup> in men and 95 g/m<sup>2</sup> in women<sup>21</sup>.

The relative thickening of the ventricular wall (cm) was calculated by the formula: **2LVPW/LVDD**, which allows to categorize the LVH in concentric if greater than 0.42 or eccentric  $\leq 0.42$ , and allows the identification of concentric remodeling when the ventricular mass is normal with an increase in the relative thickening of the ventricular wall<sup>22,23</sup>.

The existence of systolic dysfunction was identified in cases in which the left ventricular ejection fraction (LVEF) was less than 50%.

### Statistical analysis

The statistical analysis was performed using the EPIDAT 3.0 program. Methods, procedures and techniques according to the use of descriptive statistics were employed.

For the description of continuous variables, the statistical functions of mean and standard deviations were used, and for the qualitative variables, the frequency distribution.

In estimating the usefulness of the ECG, there were calculated: sensitivity, specificity, positive and negative predictive values, accuracy, positive and negative likelihood ratios.

**Tabla 1.** Descripción de variables clínicas de la población de estudio (n=80).

Variables clínicas	Valor
Edad (años)	51 ± 15,8
Edad > 45 años	53 (66)
Sexo (masculino)	49 (61)
Tiempo en diálisis (años)	5 ± 3,9
Tiempo en diálisis > 5 años	34 (42)
Hipertensión arterial	60 (75)
Diabetes mellitus	15 (18)
Cardiopatía isquémica	14 (17)
Tabaquismo	34 (42)
Tratamiento hipotensor	64 (80)
Tratamiento antiisquémico	41 (51)
Tratamiento antiarrítmico	18 (22)
Índice masa corporal (kg/m <sup>2</sup> )	21 ± 3,1

Los datos expresan n (%) y media ± desviación estándar.

## RESULTS

In the **table 1**, a quantitative and qualitative description of the clinical variables of the total study population (80 cases) was developed, where a predominance of the population over 45 years of age (66%), male (61%) and the presence of HBP (75%) was observed.

In the **table 2**, a description of the echocardiographic and electrocardiographic parameters is showed. The predominant pattern found in the echocardiogram was the LVH (71%), consistent with an increase in the left ventricular mass index in both women (139 ± 41,9 g/m<sup>2</sup>) and men (144 ± 57,6 g/m<sup>2</sup>). The predominant descriptive pattern to the ECG was

the biatrial growth (46%) and LVH (41%) (**Figure**).

Of the 80 patients that made up the studied population, 33 (41%) presented LVH by the ECG (**Table 3**). Seven electrocardiographic criteria for LVH were analyzed in these 33 patients, within which the Voltage criterion of Sokolow-Lyon (84%) prevailed. Of them, 16 patients were diagnosed by the Romhilt-Estes score, which includes the analysis of six diagnostic criteria, among which was a prevalence of the left ventricular systolic overload (81%).

In the **table 4** is shown the analysis of the usefulness of the seven criteria evaluated for the electrocardiographic diagnosis of LVH, individually and collectively. All the criteria presented high specificity and high positive predictor values (greater than 85%), and a positive likelihood ratio > 3. When ana-

**Tabla 2.** Población de estudio. Descripción de variables ecocardiográficas y electrocardiográficas.

Variables	Valor
<b>Ecocardiográficas</b>	
Hipertrofia ventricular izquierda	57 (71)
Remodelado concéntrico del VI	13 (16)
Disfunción sistólica del VI	12 (15)
Disfunción diastólica del VI	46 (57)
Índice de masa del VI en hombres (g/m <sup>2</sup> )*	144 ± 57,6
Índice de masa del VI en mujeres (g/m <sup>2</sup> )*	139 ± 41,9
GRP del VI en hombres (cm)	0,50 ± 0,1
GRP del VI en mujeres (cm)	0,49 ± 0,1
DDVI en hombres (cm/m <sup>2</sup> )**	2,7 ± 0,5
DDVI en mujeres (cm/m <sup>2</sup> )**	2,9 ± 0,4
<b>Electrocardiográficas</b>	
Crecimiento biauricular	37 (46)
Crecimiento auricular izquierdo	23 (28)
Hipertrofia ventricular izquierda	33 (41)
Bloqueos de rama***	6 (7)

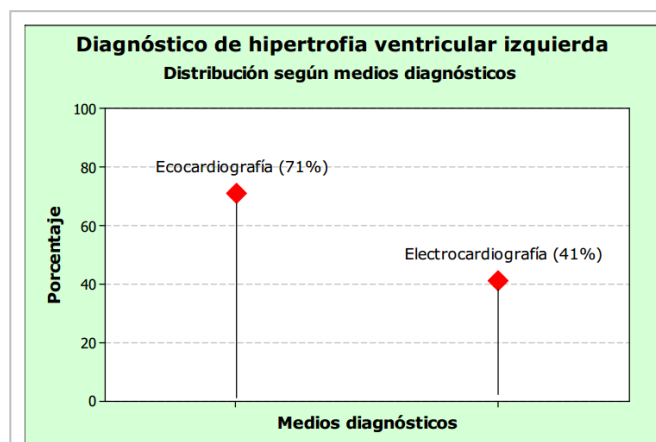
Los datos expresan n (%) y media ± desviación estándar.

\*Valores de referencia: <95 g/m<sup>2</sup> en mujeres y <115 g/m<sup>2</sup> en hombres.

\*\*Valores de referencia: rangos de 2.4-3.2 cm/m<sup>2</sup> en mujeres y 2.2-3.1 cm/m<sup>2</sup> en hombres.

\*\*\*Se diagnosticaron 2 casos con bloqueo de rama derecha, 3 con bloqueo fascicular anterior izquierdo y uno con bloqueo del fascículo posterior.

DDVI, diámetro diastólico del ventrículo izquierdo; GRP, grosor relativo de la pared; VI, ventrículo izquierdo.



**Figura.** Diagnóstico de hipertrofia ventricular izquierda según medios diagnósticos.

**Tabla 3.** Diagnóstico electrocardiográfico de hipertrofia ventricular izquierda. Distribución según criterios diagnósticos.

Variables	Valor
<b>Criterios electrocardiográficos de HVI n=33</b>	
Voltaje de Sokolow-Lyon	28 (84)
Voltaje de Cornell	18 (54)
Producto de Sokolow-Lyon	17 (51)
Puntuación de Romhilt-Estes	16 (48)
Producto de Cornell	14 (42)
Voltaje de R aVL	12 (36)
Criterio de Gubner	10 (30)
<b>Criterios diagnósticos de la puntuación de Romhilt-Estes n=16</b>	
Sobrecarga sistólica ventricular izquierda	13 (81)
Crecimiento aurícula izquierda	11 (68)
Voltaje de onda R o S	10 (62)
QRS ancho	8 (50)
Eje del QRS ≥ -30°	1 (6)
Deflexión intrinsecoide del QRS	1 (6)

Los datos expresan n (%).

lyzing the ECG in general by analyzing the group of criteria, the sensitivity of the test reached 50%.

The usefulness of the ECG in the diagnosis of the type of LVH was better for the concentric forms (**Table 5**) when comparing the specificity and the



positive predictive values obtained. The voltage criterion of Sokolow-Lyon (48%) and the group of criteria (55%) showed the highest sensitivity and the voltage criterion of Sokolow-Lyon showed improved positive predictive value (84%) for concentric diagnose forms of LVH, followed by the Cornell voltage (82%) and the group of criteria (82%)

In the **table 6** is shown the usefulness of the ECG in the diagnosis of the severity of LVH. The ECG, generally, by analyzing the set of criteria, showed more sensitivity in the diagnosis of severe LVH that in the non-severe. The voltage criterion R in aVL

showed the highest specificity (93%), better positive predictive value (90%) for the diagnosis of severe forms of the disease.

## DISCUSSION

In this research, the HBP was the main cause of CKD, while the diabetes mellitus ranked fourth. These two known diseases are cited in national and

**Tabla 4.** Utilidad del electrocardiograma en el diagnóstico de hipertrofia ventricular izquierda.

Criterios electrocardiográficos diagnósticos de HVI	S (%)	E (%)	VPP (%)	VPN (%)	Exactitud	LR +	LR -
Puntuación de Romhilt-Estes	26	95	93	34	0,46	6,1	0,8
Voltaje de Sokolow-Lyon	43	86	89	38	0,56	3,4	0,7
Producto de Sokolow-Lyon	24	95	93	33	0,45	5,7	0,8
Voltaje de Cornell	29	95	94	35	0,48	6,9	0,7
Producto de Cornell	22	95	92	33	0,43	5,3	0,8
Criterio de Gubner	15	95	90	31	0,38	3,6	0,9
Voltaje R aVL	17	95	90	31	0,40	4,0	0,9
Conjunto de criterios	50	82	87	40	0,60	2,9	0,6

E, especificidad; HVI, hipertrofia ventricular izquierda; LR+, razón de probabilidades (*likelihood ratio*) positivo; LR-, razón de probabilidades (*likelihood ratio*) negativo; S: sensibilidad; VPN: valor predictivo negativo; VPP: valor predictivo positivo.

**Tabla 5.** Utilidad del electrocardiograma en el diagnóstico del tipo de hipertrofia ventricular izquierda (comparación con ecocardiografía).

Criterios electrocardiográficos de hipertrofia ventricular izquierda	Hipertrofia ventricular izquierda en el ecocardiograma							
	Concéntrica				Excéntrica			
	S	E	VPP	VPN	S	E	VPP	VPN
Puntuación de Romhilt-Estes	27	78	80	26	21	72	20	73
Voltaje de Sokolow-Lyon	48	71	84	31	28	51	16	68
Producto de Sokolow-Lyon	25	78	78	25	21	74	21	74
Voltaje de Cornell	32	78	82	27	21	67	17	72
Producto de Cornell	23	78	76	25	21	76	23	75
Criterio de Gubner	14	78	66	22	21	86	33	77
Voltaje R aVL	16	78	70	23	21	83	30	76
Conjunto de criterios	55	64	82	32	35	42	17	67

Los datos expresan %.

E, especificidad; S, sensibilidad; VPP, valor predictivo positivo; VPN, valor predictivo negativo.

**Tabla 6.** Utilidad del electrocardiograma en el diagnóstico de la gravedad de la hipertrofia ventricular izquierda (comparación con ecocardiografía).

Criterios electrocardiográficos de hipertrofia ventricular izquierda	Hipertrofia ventricular izquierda en el ecocardiograma							
	Grave				No grave			
	S	E	VPP	VPN	S	E	VPP	VPN
Puntuación de Romhilt-Estes	28	80	80	28	20	71	20	71
Voltaje de Sokolow-Lyon	47	66	80	31	33	52	68	47
Producto de Sokolow-Lyon	26	80	78	27	20	73	21	72
Voltaje de Cornell	35	86	88	32	20	64	16	69
Producto de Cornell	26	86	84	29	20	73	21	72
Criterio de Gubner	19	93	88	29	6	81	11	70
Voltaje R aVL	23	<b>93</b>	<b>90</b>	30	6	76	69	23
Conjunto de criterios	54	60	79	32	40	45	67	54

Los datos expresan %.

E, especificidad; S, sensibilidad; VPP, valor predictivo positivo; VPN, valor predictivo negativo.

international reports among the leading causes of CKD<sup>24-27</sup>.

In Cuba, according to data from the statistical<sup>28</sup> yearbook, the HBP exceeds the diabetes mellitus as cause of CKD and this may be due to the prevalence of HBP in our environment, as well as to its ineffective control.

The average age of the studied population was 51 years, similar to that of other research<sup>15,29,30</sup>. There is a wide range in terms of age averages in the different works. Some report higher averages of age<sup>27,31-33</sup> and others lower than the one found in this study<sup>34,35</sup>. The variation of age, sex and causes of terminal CKD in the different studies could be influenced by other factors, such as survival in dialysis centers and by the types of research design. Overall, publications in hemodialysis patients show a predominance of males<sup>15,27,29,31</sup>.

The HBP was the associated comorbidity that prevailed. This disease is the most common atherogenic risk factor and its prevalence as comorbidity fluctuates between 80-90%, with variability between dialysis units and countries<sup>36</sup>. In the general population of Cuba, the HBP is present in 21, 25% of people over 15 years of age<sup>37</sup>; however, in this research was found in 75% of the population under study.

Its high frequency in this type of population is linked to the appearance of LVH. The presence of this complication has been known as a predictor of cardiac death in dialysis patients<sup>38</sup> and its progression has been clearly related to the risk of sudden

death<sup>39</sup>. Also, the regression of LVH with treatment is associated with improved survival<sup>40,41</sup>. It has also been informed that, by the echocardiogram, at the beginning of the dialysis about 75% of adults have CKD and LVH<sup>4,5,42</sup>. This suggests that it tends to progress from the beginning of the disease and in the literature a greater left ventricular mass index is described related to the antiquity of the CKD or to the time of permanence in dialysis<sup>40</sup>.

In this research, LVH was the main echocardiographic cardiovascular alteration detected in 71% of the cases. In both sexes, an increase of the mass index and relative wall thickness of the left ventricular was also identified.

It was further found that the ventricular diastolic dysfunction prevailed over the systolic (15% vs 57%) and in 16% of cases the concentric left ventricular remodeling was observed. Quiroga *et al.*<sup>31</sup>, in their cohort study that included 211 patients on hemodialysis, pointed out that the diastolic dysfunction is a risk factor for death and cardiovascular disease on dialysis.

Covicet *et al.*<sup>15</sup> reported, when analyzing several electrocardiographic criteria, that the frequency of LVH in this population may vary from 3.1-41.9%, and study in 2012<sup>43</sup> found LVH by ECG in 36.31% of hemodialysis patients; however, this result is lower than that found by the authors of this research where the electrocardiographic pattern of LVH was a relevant finding, when detected, by the ECG, in 41% of patients on hemodialysis.

In this study was found that the criterion of Sokolow-Lyon voltage was the best showing frequency distribution and allowed to identify LVH in 28 of the 33 patients who had LVH by ECG. This means that through the aforementioned criteria, LVH was identified in 35% of the 80 patients in the study. The other criteria that showed better distribution were the Cornell voltage, the product of Sokolow-Lyon and the Romhilt-Estes score.

In the study by Krane *et al.*<sup>38</sup>, which included only patients undergoing hemodialysis with type 2 diabetes mellitus, it was recorded a 12.4% of LVH defined through the criteria of the Sokolow-Lyon voltage. In another work<sup>12</sup>, also in hemodialysis patients, the same criterion predominated (18.9%) of other analyzed as the Sokolow-Lyon product (13.6%), the Cornell voltage (12.0%) and the Cornell product (13.6%).

On the other hand, Agarwal y Light<sup>44</sup>, in chronic kidney patients found more relevance of the Cornell criterion (14%) over the Sokolow-Lyon (10%) for the diagnosis of LVH; while in another research<sup>11</sup> performed in the general population, a frequency of LVH of 17.8% using a different and little known criterion, the Perugia index.

Regarding the Romhilt-Estes score, the criterion that showed the best frequency of distribution was that of left ventricular systolic overload. This is of great importance, since in the pattern of ventricular systolic overload, repolarization occurs with depression of the ST segment and asymmetric inversion of the T wave in the left precordial leads. This may indicate LVH and myocardial ischemia. At present, it is considered, according to Bayés de Luna<sup>45</sup>, that the pattern of left ventricular overload seems to be more related to the duration of the disease than to the different types of hemodynamic overload and may change during the evolution of the disease.

Kannel *et al.*<sup>46</sup> noted that from the Framingham study it is known that the presence of LVH in the ECG represents an increase in the coronary risk of 3 to 5.8 times. These authors also confirm that the risk of developing heart failure was higher in the presence of an ECG consistent with LVH than with the growing of the cardiac area on a chest radiograph. The ECG, therefore, has an additional prognostic value.

In the LIFE<sup>22</sup> study, the pattern of overload observed in 971 of the 8854 patients evaluated over a five-year period was associated with an increase in cardiovascular mortality, 2.2 times, risk of myocardial infarction, 2 times, and risk of stroke, 1.7 times.

The ECG is undoubtedly less sensitive than the transthoracic echocardiography for the diagnosis of LVH; However, when the hypertrophy is detected by ECG, it implies a poor prognosis<sup>13</sup>. The presence of a pattern of left ventricular systolic overload in V<sub>5</sub> and V<sub>6</sub> should be taken into account in patients with transplant criteria, as they should be prioritized. Patients who exhibit this easy-to-recognize electrocardiographic pattern have a significant increase in the cardiovascular risk compared to those who do not.

In this study, the ECG, in general, showed a sensitivity of 50% and a specificity of 82%. The positive predictive value of the test reached 87%. These results probably reflect the seriousness of the LVH of patients on hemodialysis.

The Sokolow-Lyon voltage was the criterion which showed higher sensitivity (43%) and high specificity (86%) and positive (89%) predictive value. The Cornell voltage was the other criteria that, although showed lower sensitivity (29%) than the first, had high specificity (95%) and the highest positive predictive value (94%). In general, all electrocardiographic criteria for LVH showed high positive predictive values and a likelihood ratio > 3.

In a study that included 120 patients with aortic valve disease, the different electrocardiographic diagnostic criteria were compared. The one from Romhilt-Estes showed the highest sensitivity, specificity and positive predictive value (66%, 85% and 91%, respectively)<sup>47</sup>. In another research<sup>48</sup> that included 288 hypertensive patients, four electrocardiographic criteria were analyzed of LVH and there was found that the Sokolow-Lyon voltage and its product, and the Cornell voltage and its product had all low sensitivity (28.7%, 36.8%, 21% and 31.1%, respectively) and high specificity (92.1%; 91.4%, 94.8% and 91.4%, respectively).

In this research, it was found that the criterion of the Sokolow-Lyon voltage and the ECG in general (to analyze the set of electrocardiographic criteria of LVH) were useful to identify the concentric shapes of LVH to display a high positive predictive value (84% and 82%, respectively); while the voltage of R aVL was the criterion which showed higher specificity (93%) and the highest positive (90%) predictive value for identifying serious forms of LVH.

This result has, in the opinion of the authors, great clinical importance. The identification by the ECG of severe and concentric forms of LVH, as well as a systolic left ventricular overload pattern, can help to predict the cardiovascular risk of these pa-



tients and to establish protocols of action to improve the survival of patients with CKD on hemodialysis.

## CONCLUSIONS

The electrocardiogram is a useful diagnostic tool and it is available in dialysis units to certify the existence of left ventricular hypertrophy in patients with terminal chronic kidney disease on hemodialysis. The diagnostic utility of the electrocardiogram is greater to identify concentric and severe forms of left ventricular hypertrophy.

## REFERENCES

1. Kanbay M, Afsar B, Goldsmith D, Covic A. Sudden death in hemodialysis: An Update. *Blood Purif.* 2010;30(2):135-45.
2. Bright R. Cases and observations, illustrative of renal disease accompanied with the secretion of albuminous urine. *Guy's Hosp Rep* [Internet]. 1836 [citado 22 Ago 2017];1(2):338-379. Disponible en: <https://babel.hathitrust.org/cgi/pt?id=iau.31858046169490;view=1up;seq=390>
3. Middleton RJ, Parfrey PS, Foley RN. Left ventricular hypertrophy in the renal patient. *J Am Soc Nephrol.* 2001;12(5):1079-84.
4. Foley RN, Parfrey PS, Harnett JD, Kent GM, Murray DC, Barré PE. The prognostic importance of left ventricular geometry in uremic cardiomyopathy. *J Am Soc Nephrol.* 1995;5(12):2024-31.
5. Levin A, Thompson CR, Ethier J, Carlisle EJ, Tobe S, Mendelssohn D, et al. Left ventricular mass index increase in early renal disease: Impact of decline in hemoglobin. *Am J Kidney Dis.* 1999;34(1):125-34.
6. Truong QA, Ptaszek LM, Charipar EM, Taylor C, Fontes JD, Kriegel M, et al. Performance of electrocardiographic criteria for left ventricular hypertrophy as compared with cardiac computed tomography: from the Rule Out Myocardial Infarction Using Computer Assisted Tomography trial. *J Hypertens.* 2010;28(9):1959-67.
7. Levy D, Labib SB, Anderson KM, Christiansen JC, Kannel WB, Castelli WP. Determinants of sensitivity and specificity of electrocardiographic criteria for left ventricular hypertrophy. *Circulation.* 1990;81(3):815-20.
8. Calderón A, Barrios V, Escobar C, Ferrer E, Barrios S, González-Pedel V, et al. Detection of left ventricular hypertrophy by different electrocardiographic criteria in clinical practice. Findings from the Sara study. *Clin Exp Hypertens.* 2010;32(3):145-53.
9. Okin PM, Roman MJ, Devereux RB, Kligfield P. Electrocardiographic identification of increased left ventricular mass by simple voltage-duration products. *J Am Coll Cardiol.* 1995;25(2):417-23.
10. Smilde TD, Asselbergs FW, Hillege HL, Voors AA, Kors JA, Gansevoort RT, et al. Mild renal dysfunction is associated with electrocardiographic left ventricular hypertrophy. *Am J Hypertens.* 2005;18(3):342-7.
11. Verdecchia P, Schillaci G, Borgioni C, Ciucci A, Gattobigio R, Zampi I, et al. Prognostic value of a new electrocardiographic method for diagnosis of left ventricular hypertrophy in essential hypertension. *J Am Coll Cardiol.* 1998;31(2):383-90.
12. Kim SJ, Oh HJ, Yoo DE, Shin DH, Lee MJ, Kim HR, et al. Electrocardiographic left ventricular hypertrophy and outcome in hemodialysis patients. *PLoS ONE* [Internet]. 2012 [citado 22 Ago 2017];7(4):e35534. Disponible en: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3328457/pdf/pone.0035534.pdf>
13. Costa F de A, Rivera IR, Vasconcelos ML, Costa AF, Póvoa RM, Bombig MT, et al. Electrocardiography in the diagnosis of ventricular hypertrophy in patients with chronic renal disease. *Arq Bras Cardiol.* 2009;93(4):353-9.
14. Cordeiro AC, Moraes AA, Cerutti V, França F, Quiroga B, Amodeo C, et al. Clinical determinants and prognostic significance of the electrocardiographic strain pattern in chronic kidney disease patients. *J Am Soc Hypertens.* 2014;8(5):312-20.
15. Covic AC, Buimistriuc LD, Green D, Stefan A, Badarau S, Kalra PA. The prognostic value of electrocardiographic estimation of left ventricular hypertrophy in dialysis patients. *Ann Noninvasive Electrocardiol.* 2013;18(2):188-98.
16. Kligfield P, Gettes LS, Bailey JJ, Childers R, Deal BJ, Hancock EW, et al. Recommendations for the standardization and interpretation of the electrocardiogram. Part I: The electrocardiogram and its technology: A scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Car-

- diology; the American College of Cardiology Foundation; and the Heart Rhythm Society. *Circulation*. 2007;115(10):1306-24.
17. Hancock EW, Deal BJ, Mirvis DM, Okin P, Kligfield P, Gettes LS, *et al*. AHA/ACCF/HRS Recommendations for the standardization and interpretation of the electrocardiogram. Part V: Electrocardiogram changes associated with cardiac chamber hypertrophy: A scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society. *J Am Coll Cardiol*. 2009;53(11):992-1002.
  18. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, *et al*. Recommendations for chamber quantification. *Eur J Echocardiogr*. 2006;7(2):79-108.
  19. Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man. Anatomic validation of the method. *Circulation*. 1977;55(4):613-8.
  20. Devereux RB, Alonso DR, Lutas EM, Gottlieb GJ, Campo E, Sachs I, *et al*. Echocardiographic assessment of left ventricular hypertrophy: Comparison to necropsy findings. *Am J Cardiol*. 1986; 57(6):450-8.
  21. Koren MJ, Devereux RB, Casale PN, Savage DD, Laragh JH. Relation of left ventricular mass and geometry to morbidity and mortality in uncomplicated essential hypertension. *Ann Intern Med*. 1991;114(5):345-52.
  22. Okin PM, Devereux RB, Jern S, Julius S, Kjeldsen SE, Dahlöf B. Relation of echocardiographic left ventricular mass and hypertrophy to persistent electrocardiographic left ventricular hypertrophy in hypertensive patients: the LIFE Study. *Am J Hypertens*. 2001;14(8 Pt 1):775-82.
  23. Ganau A, Devereux RB, Roman MJ, de Simone G, Pickering TG, Saba PS, *et al*. Patterns of left ventricular hypertrophy and geometric remodeling in essential hypertension. *J Am Coll Cardiol*. 1992; 19(7):1550-8.
  24. Candebat Fernández OA, Rodríguez Bell Z, Rodríguez Bell V, Torres Candebat F, Callejas Candebat S. Tratamiento hemodialítico y evolución de los ancianos con insuficiencia renal crónica. *MEDISAN* [Internet]. 2009 [citado 30 Ago 2017];13(5). Disponible en: <http://scielo.sld.cu/pdf/san/v13n5/san02509.pdf>
  25. Astan R, Akpınar I, Karan A, Kacmaz F, Sokmen E, Baysal E, *et al*. The effect of hemodialysis on electrocardiographic parameters. *Ann Noninvasive Electrocardiol*. 2015;20(3):253-7.
  26. Dalas M, Vázquez A, Fernández Y, Guerra G. Comportamiento de factores pronósticos de morbilidad y mortalidad en una Unidad de Hemodiálisis. *Rev Cubana Med* [Internet]. 2008 [citado 22 Ago 2017];47(3). Disponible en: <http://scielo.sld.cu/pdf/med/v47n3/med01308.pdf>
  27. Burton JO, Korsheed S, Grundy BJ, McIntyre CW. Hemodialysis-induced left ventricular dysfunction is associated with an increase in ventricular arrhythmias. *Ren Fail*. 2008;30(7):701-9.
  28. Anuario Cuba Nefro-Red 2014. Situación de la Enfermedad Renal Crónica en Cuba 2014. 3er Año [Internet]. 2015 [citado 30 Ago 2017]. Disponible en: <http://files.sld.cu/nefrologia/files/2015/09/anuario-nefrologia-2014-pagina-web-especialidad.pdf>
  29. Bozbas H, Atar I, Yildirim A, Ozgul A, Uyar M, Ozdemir N, *et al*. Prevalence and predictors of arrhythmia in end stage renal disease patients on hemodialysis. *Ren Fail*. 2007;29(3):331-9.
  30. Kaze FF, Kengne AP, Djalloh AM, Ashuntantang G, Halle MP, Menanga AP, *et al*. Pattern and correlates of cardiac lesions in a group of sub-Saharan African patients on maintenance hemodialysis. *Pan Afr Med J* [Internet]. 2014 [citado 22 Ago 2017];17:3. Disponible en: <http://www.panafrican-med-journal.com/content/article/17/3/pdf/3.pdf>
  31. Quiroga B, Villaverde M, Abad S, Vega A, Reque J, López-Gómez J M. Diastolic dysfunction and high levels of new cardiac biomarkers as risk factors for cardiovascular events and mortality in hemodialysis patients. *Blood Purif*. 2013;36(2):98-106.
  32. Genovesi S, Rossi E, Nava M, Riva H, de Franceschi S, Fabbrini P, *et al*. A case series of chronic haemodialysis patients: Mortality, sudden death, and QT interval. *Europace*. 2013;15(7):1025-33.
  33. Valentim B, Pereira A, Coelho P, Pereira T. Study of ventricular electrical systole in patients with end-stage kidney disease on hemodialysis. *Arq Bras Cardiol*. 2013;100(3):261-8.
  34. Mohi-ud-din K, Bali HK, Banerjee S, Sakhuja V, Jha V. Silent myocardial ischemia and high-grade ventricular arrhythmias in patients on maintenance hemodialysis. *Ren Fail*. 2005;27(2):171-5.
  35. Stewart GA, Gansevoort RT, Mark PB, Rooney E, McDonagh TA, Dargie HJ, *et al*. Electrocardiographic abnormalities and uremic cardiomyopathy. *Kidney Int*. 2005;67(1):217-26.

36. Gorsane I, Mahfoudhi M, Younsi F, Helal I, Abdallah TB. Prevalence and risk factors of hypertension in hemodialysis. *Open J Nephrol* [Internet]. 2015 [citado 22 Ago 2017];5:54-60. Disponible en: [http://file.scirp.org/pdf/OJNeph\\_2015061615315861.pdf](http://file.scirp.org/pdf/OJNeph_2015061615315861.pdf)
37. Ministerio de Salud Pública. Anuario Estadístico de Salud 2014. La Habana: Dirección Nacional de Registros Médicos y Estadísticas de Salud; 2015.
38. Krane V, Heinrich F, Meesmann M, Olschewski M, Lilienthal J, Angermann C, et al. Electrocardiography and outcome in patients with diabetes mellitus on maintenance hemodialysis. *Clin J Am Soc Nephrol*. 2009;4(2):394-400.
39. Paoletti E, Specchia C, Di Maio G, Bellino D, Damasio B, Cassottana P, et al. The worsening of left ventricular hypertrophy is the strongest predictor of sudden cardiac death in haemodialysis patients: A 10 year survey. *Nephrol Dial Transplant*. 2004;19(7):1829-34.
40. Glassock RJ, Pecoits-Filho R, Barberato SH. Left ventricular mass in chronic kidney disease and ESRD. *Clin J Am Soc Nephrol*. 2009;4(Supl 1):S79-91.
41. London GM, Pannier B, Guerin AP, Blacher J, Marchais SJ, Darne B, et al. Alterations of left ventricular hypertrophy in and survival of patients receiving hemodialysis: Follow-up of an interventional study. *J Am Soc Nephrol*. 2001;12(12):2759-67.
42. Taddei S, Nami R, Bruno RM, Quatrini I, Nuti R. Hypertension, left ventricular hypertrophy and chronic kidney disease. *Heart Fail Rev*. 2011;16(6):615-20.
43. Bignotto LH, Kallás ME, Djouki RJ, Sasaki MM, Voss GO, Soto CL, et al. Electrocardiographic findings in chronic hemodialysis patients. *J Bras Nefrol*. 2012;34(3):235-42.
44. Agarwal R, Light RP. Determinants and prognostic significance of electrocardiographic left ventricular hypertrophy criteria in chronic kidney disease. *Clin J Am Soc Nephrol*. 2011;6:528-36.
45. Bayés de Luna A. Electrocardiografía clínica. 7ª ed. Barcelona: Wiley-Blackwell; 2012. p. 127-63.
46. Kannel WB, Levy D, Cupples LA. Left ventricular hypertrophy and risk of cardiac failure: insights from the Framingham Study. *J Cardiovasc Pharmacol*. 1987;10(Supl 6):S135-40.
47. Buchner S, Debl K, Haimerl J, Djavidani B, Poschenrieder F, Feuerbach S, et al. Electrocardiographic diagnosis of left ventricular hypertrophy in aortic valve disease: evaluation of ECG criteria by cardiovascular magnetic resonance. *J Cardiovasc Magn Reson* [Internet]. 2009 [citado 30 Ago 2017];11:18. Disponible en: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2696426/pdf/1532-429X-11-18.pdf>
48. Alfakih K, Walters K, Jones T, Ridgway J, Hall AS, Sivananthan M. New gender-specific partition values for ECG criteria of left ventricular hypertrophy: recalibration against cardiac MRI. *Hypertension*. 2004;44(2):175-9.