Left Ventricular Hypertrophy in the Spanish Hypertensive Population. The ERIC-HTA Study

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Introduction and objectives. Left ventricular hypertrophy (LVH) is the earliest manifestation of cardiac damage in hypertension. Its appearance is associated with a poor cardiovascular prognosis. The objectives of this study were to determine the prevalence of electrocardiographic LVH and to assess the epidemiological characteristics of hypertensive patients receiving primary care.

Patients and method. A cross-sectional multicenter study of hypertensive patients aged 55 years or more was carried out in a primary care setting. Blood pressure was measured using the standard method. Cardiovascular history was determined from medical records and LVH was assessed electrocardiographically using Cornell’s criteria.

Results. In total, 15,798 patients (mean age 68.0 years, 55.3% women, and 30.4% with diabetes mellitus) were evaluated. Of these, 3207 (20.3%) had electrocardiographic signs of LVH. The prevalence was higher in males, diabetics, smokers, and patients with high blood pressure or renal or cardiovascular disease. Compared to patients without LVH, those with the condition were older, were more often male, and were more likely to have diabetes or renal or cardiovascular disease. Multivariate analysis showed that LVH was independently associated with advanced age, male gender, diabetes, smoking, poor blood pressure control, and the presence of cardiovascular or renal disease. Blood pressure control was poorer in patients with LVH than in those without it.

Conclusions. The prevalence of electrocardiographic LVH is high, with affected patients being more likely to have diabetes or renal or cardiovascular disease. Moreover, blood pressure control is poor in these patients, and more aggressive pharmacological management is needed.

Key words: Hypertension. Left ventricular hypertrophy. Cardiovascular risk. Blood pressure control.

Introducción y objetivos. El objetivo del presente estudio fue evaluar la prevalencia de hipertrofia del ventrículo izquierdo (HVI) en el electrocardiograma y el perfil epidemiológico en pacientes hipertensos atendidos en atención primaria.

Pacientes y método. Estudio transversal, multicéntrico, realizado en 15,798 pacientes hipertensos ≥ 55 años de centros de atención primaria. Se midió la presión arterial y se recogieron los antecedentes cardiovasculares de la historia clínica de los pacientes. La HVI se evaluó según los criterios de Cornell.

Resultados. Se evaluó a 15,798 pacientes (edad media, 68.0 años; 55.3% mujeres; 30.4% diabéticos). El 20,3% presentó HVI en el electrocardiograma. La prevalencia fue mayor en varones, diabéticos, fumadores, pacientes con enfermedad cardiovascular. Respecto a los pacientes sin HVI, los pacientes con HVI eran de edad más avanzada, con diabetes mellitus (el 40,5 frente al 27,8%), enfermedad renal (el 34,2 frente al 26,9%) y enfermedad cardiovascular (el 52,1 frente al 20,2%). En el análisis multivariante, la HVI se asoció, de forma independiente, con una edad más avanzada, el sexo masculino, la diabetes, el tabaquismo, la ausencia de control de la presión arterial, y la presencia de enfermedad cardiovascular y renal. El porcentaje de pacientes que cumplían objetivos de control de presión arterial fue menor entre los pacientes con HVI respecto a aquellos sin HVI.

Conclusions. La prevalencia de HVI en el electrocardiograma es elevada y se asocia con una mayor preva-
As recently demonstrated, electrocardiographic
left ventricular hypertrophy (LVH) detected via 
electrocardiogram (ECG) or echocardiogram is the 
earliest manifestation of cardiac damage in patients with 
arterial hypertension (AHT). Electrocardiographic LVH is 
also an independent risk factor for cardiovascular 
complications, especially cerebrovascular ones, in the 
hypertensive population.1,2 In addition, patient prognosis 
is determined by how electrocardiographic LVH evolves 
and its regression leads to a reduction in cardiovascular 
complications.3,4 As recently demonstrated, electrocardiographic LVH regression predicts regression in the 
echocardiogram,5 and thus ECG appears to be a good 
follow-up method for this group of patients.

Clinical practice guidelines agree that the aim of 
treatment in hypertensive patients should be not only to 
control blood pressure (BP), but protect the target organs 
affected by hypertension and reduce associated morbidity 
and mortality.5,6 The latest European guideline also 
emphasizes that the global assessment of cardiovascular 
risk in the hypertensive patient includes the identification 
of lesions caused by AHT in the target organs.3 Due to its 
wide availability, the ECG is of particular interest in 
evaluating and treating the hypertensive patient.

The ERIC-AHT study was designed to estimate stroke 
risk in the Spanish hypertensive population treated in 
health centers.7 One of the parameters assessed to 
estimate stroke risk is electrocardiographic LVH.4 The 
aim of the present study is to assess the prevalence of 
electrocardiographic LVH and the demographic and 
clincial characteristics of patients in this population.

**PATIENTS AND METHOD**

The ERIC-AHT is a cross-sectional multicenter 
epidemiological study of 16,703 patients carried out in 
primary care centers throughout Spain by approximately 
1,600 physicians.7 The study was approved by an 
independent clinical research ethics committee and 
informned consent was given by the participating patients. 
The data collection period was from June to October 2003.

The study included all hypertensive patients ≥55 years 
of age, whether treated with antihypertensive drugs or not, 
and undiagnosed or untreated patients who began 
antihypertensive treatment on the day data were 
collected. Demographic and anthropometric data were 
collected as well as those concerning cardiovascular risk 
factors and a history of cardiovascular disease. 
Biochemical data were obtained from the patient’s 
medical record and a blood test done 6 months prior to 
data collection. The study was provided with the 
OMRON® M5 semi-automatic blood pressure monitor 
which was used to obtain systolic blood pressure (SBP) 
and diastolic blood pressure (DBP). The cuff was 
matched to the perimeter of the arm. After the patient 
rested for 5 min, 3 BP measurements were done each 
separated by 2 min. The mean of the last 2 
measurements was calculated and taken as the patient’s 
BP. Blood pressure control was considered to have been 
achieved if this was <140/90 mm Hg in non-diabetic 
patients or <130/80 mm Hg in those with diabetes.

The presence of LVH was assessed via ECG in all 
the patients and evaluated by each investigator. 
Electrocardiographic LVH was diagnosed according to 
Cornell criteria: R wave in lead aVL+S wave in lead 
V3>28 mm in males and >20 mm in females.7 Atrial 
fibrillation was also assessed via ECG. Serum creatinine 
levels were evaluated 6 months prior to data collection, 
and renal function was estimated via the glomerular 
filtration rate (GFR) calculated with a simplified version 
of Levey’s formula.8,9

**Statistical Analysis**

The sample size was calculated according to the main 
aim of the study; to estimate stroke risk in the 
hypertensive population ≥55 years old with a 50% stroke 
risk (risk level assumed in a large sample) based on the 
10-year risk of stroke (range, 1%–80%) described in the 
Framingham study. The sample size was calculated at 14 
000 patients. This was done at a 95% confidence interval 
(CI) with a maximum sampling error of 0.83%.

Qualitative variables are presented with their 
frequency distribution. Quantitative variables are 
presented as mean ± standard deviation (SD) and range. 
The relationship between qualitative variables was 
assessed with the χ² test or Fisher exact test. Each 
quantitative independent variable was analyzed with the 
Mann Whitney U test or median test.

In all cases the distribution of the variable was 
compared to theoretical models and the assumption of 
homogeneity of variance was tested. The null hypothesis 
was rejected in all tests with a type I or alpha error.
The SAS version 8.02 software package was used.

RESULTS
Descriptive Data of the Total Sample
Data on 16,129 patients were collected which was valid for 15,798 patients for the ECG analysis (97.9% of the sample, 55.3% females and 44.7% males; mean age, 68.0±8.1 years; range, 55-99). Of these, 30.4% had diabetes and 17.4% were smokers.

Prevalence of Electrocardiographic Left Ventricle Hypertrophy
Electrocardiographic LVH was found in 3,207 patients (prevalence, 20.3%; 95% CI, 19.7-20.9). Figure 1 shows the prevalence of LVH stratified by age, sex, and presence or not of diabetes mellitus in males (A) and females (B). LVH indicates left ventricular hypertrophy.

Descriptive Data of Patients With Left Ventricle Hypertrophy
Table 1 presents the descriptive data of hypertensive patients with electrocardiographic LVH compared to those without hypertrophy. The LVH patients were older than those without LVH (mean age, 69.5±8.1 vs 67.6±8.0 years; P<.001) and there was a greater percentage of males (51.6% vs 43.0% in patients without LVH; P<.001). Of the LVH patients, 40.5% had diabetes mellitus versus 27.8% of subjects those without LVH (P<.001). Left ventricular hypertrophy patients had slightly higher serum creatinine levels and slightly lower GFR. Kidney failure was more prevalent among the LVH patients (defined by a GFR<60 mL/min/1.73 m²) than in those without LVH (34.2% vs 26.9%; P<.001). There were no differences in the prevalence of excess weight or obesity.

History of Cardiovascular Disease
Table 2 presents the prevalence of a history of cardiovascular disease in patients with and without LVH. The prevalence of any cardiovascular disease was greater in LVH patients (52.1 vs 20.2% in patients without LVH; P<.001). Of the LVH patients, 12.2% had a history of myocardial infarction, 21.2% angina, 26.4% heart failure, 17.7% atrial fibrillation, 7.7% stroke, and 12.2% intermittent claudication. In all cases, there was a significantly higher prevalence of a history of cardiovascular disease in LVH patients vs those without LVH (P<.001 for all the comparisons).

Blood Pressure Control
In LVH patients, mean SBP was 149.1±17.5 mm Hg and mean DBP 85.0±10.9 mm Hg. In patients without LVH, the mean pressures were 145.9±16.9 and 83.7±10.5 mm Hg, respectively. The differences in SBP (3.3 mm Hg; 95% CI, 2.6-3.9) and DBP (1.3; 95% CI, 0.9-1.7) were statistically significant (P<.001). There was a lower percentage of LVH patients with controlled BP (Table 1). Among non-diabetic patients with LVH, 25.1% had BP<130/80 mm Hg, whereas only 5.6% of diabetic patients had BP<130/80 mm Hg. Among patients without LVH, 31.0% of non-diabetic patients and 6.0% of diabetic patients, respectively, had controlled BP (P<.001 in non-diabetic patients, P=.60 in diabetic ones). Figure 2 presents the percentage of patients with well-controlled BP stratified by sex, presence or not of diabetes mellitus and LVH. Systolic blood pressure was controlled adequately in LVH patients (26.1% in non-diabetic patients vs 7.8% in diabetic patients) and there was a significantly higher prevalence of LVH in patients with BP above control levels versus patients with controlled BP (24.4 vs 17.2%; P<.001).
diabetic ones) than DBP (62.7% in non-diabetic patients vs 22.1% in diabetic ones). Of the LVH patients, 99.3% were on antihypertensive medication at the time of assessment, of which 46.0% received monotherapy and 54.0% combined treatment. The mean number of drugs per patient under treatment was greater in LVH patients vs patients without LVH (mean, 1.7±0.8 vs 1.5±0.7; \(P<.001\)).

In addition, for patients with a history of heart failure or with changes in renal function, a BP<130/80 mm Hg was also considered a control target. Thus, in LVH patients with diabetes and/or heart failure and/or changes in renal function, 6.6% had BP<130/80 mm Hg, whereas among LVH patients without such a background 26.2% had BP<140/90 mm Hg. Among patients without LVH, 7.5% and 31.4% reached control targets (\(P<.001\) for both comparisons).

**Multivariate Analysis**

The logistic regression model used included age, sex, smoking, diabetes mellitus, SBP control, changes in renal function (GFR<60 mL/min/1.73 m\(^2\)), cardiovascular disease and atrial fibrillation (Table 3). Left ventricular hypertrophy was independently associated with all the variables, especially with cardiovascular disease or atrial fibrillation. After adjusting for the rest of remaining variables, LVH was also independently associated with changes in renal function and poorly controlled BP.

**DISCUSSION**

This analysis of the ERIC-AHT study describes the prevalence of electrocardiographic LVH as an expression of early cardiac disease due to AHT, as well as the epidemiological pattern of these patients. Primary care physicians collected data from a sample of non-selected consecutive patients who formed a representative sample of the hypertensive population.
TABLE 3. Factors Related to Left Ventricular Hypertrophy. Multivariate Analysis. ERIC-AHT Study

<table>
<thead>
<tr>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (male vs female)</td>
<td>1.29 (1.16-1.43)</td>
</tr>
<tr>
<td>Age (1-year increment)</td>
<td>1.01 (1.01-1.02)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.33 (1.20-1.47)</td>
</tr>
<tr>
<td>Smoking</td>
<td>1.26 (1.14-1.41)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>2.47 (2.13-2.88)</td>
</tr>
<tr>
<td>Vascular disease</td>
<td>3.55 (2.22-5.91)</td>
</tr>
<tr>
<td>Uncontrolled blood pressure</td>
<td>1.37 (1.21-1.55)</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>1.28 (1.15-1.43)</td>
</tr>
</tbody>
</table>

GFR indicates glomerular filtration rate; CI, confidence interval; OR, odds ratio.

more than 55 years old treated in Spanish health centers.

Electrocardiographic LVH was found in 20.3% of the hypertensive patients. Prevalence was higher in patients at greater cardiovascular risk: males, older patients, diabetic patients and patients with uncontrolled BP. Similarly, and compared to patients without LVH, LVH patients were characterized by advanced age, a greater percentage of males and diabetic patients, poor BP control and a greater prevalence of cardiovascular and renal disease.

The electrocardiogram is the recommended screening method to evaluate the presence of LVH in hypertensive patients, although its sensitivity to detect LVH is low. The use of Cornell criteria can increase sensitivity without losing specificity. Although no internal validation versus echocardiogram was done in our study as a reference test, Cornell criteria have been evaluated and their value verified in multiple studies. When these criteria were applied, electrocardiographic LVH was reported in 20.3% of patients. In a recently published study, Pascual et al. described a similar prevalence with the same electrocardiographic criteria in normoalbuminuric patients with mild AHT, although in this study the patients had been referred to a hypertensive unit and were younger. Nevertheless, two other primary care studies report dissimilar figures regarding the prevalence of LVH. A similar figure (17.5%) was reported by Barnios et al. in the DIOIRISC study. This study included more than 9000 patients and assessed comorbidity and target organ damage. The most prevalent target organ damage in this population was LVH. However, the PRESCAP study reported a much smaller prevalence of electrocardiographic LVH (7.2%). Standardizing the definition of LVH by using Cornell criteria (or even better, the Cornell voltage duration product criteria), or by using combined criteria to define the presence of LVH (mainly Cornell and Sokolow-Lyon criteria), can increase the sensitivity of ECG to detect LVH and thus lead to better detection of patients at greater cardiovascular risk. This is particularly relevant due to the difficulties involved in carrying out systematic echocardiography in such a prevalent disease. Although the prevalence of echocardiographic LVH is much higher than that obtained by ECG, the wide availability of ECG promotes its use in any area of the health system.

In our study, patients with electrocardiographic LVH had a higher prevalence of cardiovascular risk factors as well as renal disease (defined as GFR < 60 mL/min/1.73 m²) and established cardiovascular disease. Half of the hypertensive patients with electrocardiographic LVH in our series had a cardiovascular complication in contrast to a fifth of the patients without LVH. The presence of LVH in the hypertensive patient is associated with greater cardiovascular morbidity and mortality, and is an independent risk factor for stroke. In a follow-up study of 2363 initially untreated hypertensive patients without cardiovascular disease at the beginning of the follow-up, Verdecchia et al. reported that stroke rate was almost double in LVH patients, detected by both ECG and echocardiogram compared to patients without LVH.

The detection of electrocardiographic LVH in the outpatient clinic is essential to assess patient risk and evaluate the effect of antihypertensive treatment on their evolution, since presence or absence of LVH with antihypertensive treatment has prognostic implications in these patients. Whereas electrocardiographic LVH regression is associated with a lower incidence of cardiovascular complications, morbidity and mortality is greater in patients in whom LVH does not regress or progresses. Two recent analyses of the LIFE study (Losartan Intervention For Endpoint Reduction), carried out in 9193 hypertensive patients with electrocardiographic LVH, showed that LVH regression using electrocardiographic criteria and greater left ventricular mass reduction in the echocardiogram are associated with a lower incidence of cardiovascular disease and lower mortality at follow-up. This information is of special interest regarding the choice of treatment in these patients. The metaanalysis carried out by Klingenbl et al. reported that different drug classes have different effects on LVH regression: treatment with calcium antagonists, angiotensin enzyme-converting inhibitors or angiotensin II receptor antagonists (ARA-II) yields greater LVH regression than treatment with diuretics or beta-blockers. The LIFE study reported that treatment based on the ARA-II losartan made LVH regress with more efficacy than treatment based on the beta-blocker atenolol. Over time, there was a reduction in cardiovascular morbidity and mortality and the incidence of stroke in patients treated with losartan compared to those treated with atenolol. An aspect of special interest in our study is the higher prevalence of LVH specifically in patients with greater cardiovascular risk (males, older patients, diabetic patients, and patients with poorly controlled BP). Blood pressure control in LVH patients was also worse than in...
patients without LVH, with a between-groups difference of 3.3/1.3 mm Hg. The recent ALLHAT and VALUE studies show that even small differences in BP (even lower than those detected among the patients with or without LVH in our study) can have a serious impact on the appearance of cardiovascular complications.20,21 This means that, if our population of hypertensive LVH patients is at high risk of cardiovascular events, then this risk is increased due to their higher BP levels.

However, BP control in LVH patients is complex and generally requires the use of high doses of combined drugs. By the end of the LIFE study, 88.5% of the patients treated with combined drugs and less than 25% had controlled BP. Thus, the data show that achieving therapeutic aims is difficult, especially in diabetic and LVH patients; the data also draw attention to the fact that AHT treatment should be pursued more aggressively.

The main limitation of our study is its cross-sectional nature, which places limits on calculating the prevalence of each disease. This can lead to underestimating associations between different variables, especially when some of them (as in the case of stroke) are associated with high mortality in the population presenting them. However, the broad sample of patients included in the study accurately reproduces the findings of day-to-day primary care.

In conclusion, ECG continues to be a very valuable method for detecting LVH and is an essential parameter in the measurement of cardiovascular risk in the hypertensive patient. The prevalence of electrocardiographic LVH when applying Cornell criteria is high and, due to the characteristics of these patients and the poorly controlled BP, ECG identifies a group of patients at high cardiovascular and cerebrovascular risk, as well as those with impaired renal function. Blood pressure control in these patients is difficult and requires the use of combined drugs in high doses. The use of effective drugs for LVH regression which improve cardiovascular prognosis is indicated in this group of special risk patients.

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REFERENCES


