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Original Article

Left ventricle geometric patterns in patients with or without nocturnal hypertension: Hospital Calixto García – 2016-2017

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ARTICLE INFORMATION

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The authors declare no competing interests.

Abbreviations
ABPM: ambulatory blood pressure monitoring
BMI: body mass index
DBP: diastolic blood pressure
HBP: high blood pressure
LVH: left ventricular hypertrophy
LVM: left ventricular mass
LVMI: left ventricular mass index
SBP: systolic blood pressure

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ABSTRACT

Introduction: Changes in ventricular geometry in hypertensive patients are influenced by 24-hour control of blood pressure, as well as its adequate decrease during nighttime.
Objectives: To describe the left ventricle geometric patterns in patients with or without nocturnal hypertension.
Methods: An ambulatory blood pressure monitoring (ABPM) and an echocardiogram were performed on 54 patients with high blood pressure, from 2016 to 2017. The following ABPM variables were calculated: average and pressure loads of daytime, nighttime, and 24-hour, as well as circadian pattern. In the echocardiogram, the diameters, the interventricular septum and the left ventricular posterior wall were measured; its mass and mass index were calculated, as well as determined its geometric and diastolic function patterns.
Results: The average age was 57.4%±14.1 years old. Females (57.4%) and white skin color (59.3%) predominated. Waking and nocturnal hypertension were found in 38.9% and 51.9% respectively, and the altered dipper phenomenon was found in 68.5% of the patients, significantly associated with increased nocturnal blood pressure (p=0.001). The interventricular septum was considerably higher in patients with nocturnal hypertension when compared to the group without it (11.1±2.2 vs. 9.6±1.4 mm; p=0.006). Altered geometry predominated (53.7%) at the expense of higher concentric remodeling (40.7%), without any association with nocturnal hypertension.
Conclusions: Left ventricle geometric patterns behaved similarly in patients with and without nocturnal hypertension.
Keywords: High blood pressure, Left ventricular geometry, Ambulatory blood-pressure monitoring, Echocardiography

Patrones geométricos del ventrículo izquierdo en pacientes con y sin hipertensión arterial nocturna: Hospital Calixto García – 2016-2017

RESUMEN

Introducción: En los cambios de la geometría ventricular en hipertensos influyen el control de la presión arterial durante las 24 horas del día, así como su descenso adecuado en el período nocturno.
Objetivo: Describir los patrones geométricos del ventrículo izquierdo en pacientes con y sin hipertensión arterial nocturna.

Authors' contribution
MBY and ICR: Research conception and design; data collection, analysis, interpretation and manuscript writing.
FDRM, IAAR and EKA: Raw data collection and help in writing the manuscript.
ABH: Data analysis and interpretation, and help in writing the manuscript.
All authors critically reviewed the manuscript and approved the final report.

Método: *Se realizó monitoreo ambulatorio de la presión arterial (MAPA) y ecocardiograma a 54 pacientes con hipertensión arterial del 2016 al 2017. Se calcularon las variables de MAPA: promedio y cargas de presión diurno, nocturno y 24 horas, y el patrón circadiano. En el ecocardiograma se midieron los diámetros, el tabique interventricular y la pared posterior del ventrículo izquierdo, se calculó su masa e índice de masa, y se determinó su patrón geométrico y de función diastólica.*
Resultados: *La edad promedio fue 55,4±14,1 años y predominaron el sexo femenino (57,4%) y el color de la piel blanco (59,3%). La hipertensión arterial al despertar y nocturna se halló en el 38,9% y 51,9%, respectivamente, y el fenómeno dipper alterado en 68,5% de los pacientes, asociado significativamente al incremento de la presión arterial nocturna (p=0,001). El tabique interventricular fue significativamente mayor en pacientes con hipertensión arterial nocturna en comparación con el grupo que no la presentaba (11,1±2,2 vs. 9,6±1,4 mm; p=0,006). Predominó la geometría alterada (53,7%) a expensas de mayor remodelado concéntrico (40,7%), sin asociación con la hipertensión arterial nocturna.*
Conclusiones: *Los patrones geométricos del ventrículo izquierdo se comportaron de forma similar en pacientes con y sin hipertensión arterial nocturna.*
Palabras clave: *Hipertensión arterial, Geometría ventricular izquierda, Monitoreo ambulatorio de presión arterial, Ecocardiografía*

INTRODUCTION

High blood pressure (HBP) is the most prevalent chronic disease in developed countries, afflicting more than 25% of the adult population. The World Health Organization estimates that 9.4 million people die annually from complications attributable to uncontrolled HBP[1].

Left ventricular hypertrophy (LVH) is one of the early consequences of uncontrolled HBP and is associated with increased number of coronary and cerebral ischemic events, regardless of hypertension stage and other reversible risk factors[2,3].

Echocardiography plays a key role when assessing hypertensive patients. Unlike electrocardiographic criteria, echocardiography allows for direct measurement of ventricular wall thickness and diameters and hence for calculation of left ventricular mass[4].

Clinical guidelines agree that the goal of treatment in the hypertensive patient is blood pressure control and target organ protection, in order to reduce associated morbidity and mortality[5]. Ambulatory blood pressure monitoring (ABPM) detects non-controlled patients and mainly those with nocturnal hypertension, which is associated with increased number of cardiovascular complications[6,7].

The objective of our research is to describe the left ventricular geometric patterns in hypertensive patients and relate them to the presence or not of nocturnal hypertension.

METHOD

We carried out an observational, descriptive, cross-sectional study in patients diagnosed with HBP attending the cardiology consultation of the *Hospital Universitario Clínico Quirúrgico General Calixto García*, in Havana, Cuba, in the period January 2016 - December 2017. The sample consisted of 54 hypertensive patients, divided into two groups according to the presence or not of nocturnal hypertension, who met the selection criteria: people over 18 years old, of any sex and approval expressed by signing the informed consent.

Subjects whose ABPM yielded less than 80% of valid measurements were not included. Patients with significant heart valve disease, history of ischemic heart disease or congestive heart failure, or with left ventricular wall motion abnormalities, all detected by echocardiography, were also excluded.

Variables

Clinical variables

Sociodemographic variables were: age, sex, skin color, body mass index (BMI) calculated by the Quetelet formula: BMI - weight in kilograms (kg) / square size in meters (m).

Clinical variables related to HBP were:

- Classification (by measurement in consultation): stage I (systolic blood pressure [SBP] 140-159 mmHg or diastolic blood pressure [DBP] 90-99 mmHg, stage II (SBP 160-179 mmHg or DBP 100-109 mmHg, or both), as recommended by the Na-

tional Technical Advisory Commission of the Arterial Hypertension Program of the Cuban Ministry of Public Health[9].
- Progression time: less than or equal to 5 years, from 6 to 10, from 11 to 15 and more than 15 years.
- Antihypertensive treatment: none, yes, and —among the latter— those with polypharmacy treatment (more than one antihypertensive drug).

Echocardiogram

The echocardiogram (two-dimensional echocardiography and 2D-guided M-mode method) was performed following the recommendations of the American Society of Echocardiography[4]. An Aloka Alpha 5 echocardiograph, with a 2.5 MHz transducer, was used.

Left ventricular measurements: interventricular septum (IVS), left ventricular posterior wall (LVPW) and end-diastolic diameter (LVDd), for calculation of left ventricular mass (LVM)[8]: LVM = 0.8 × [1.04 × (LVDd + IVS + LVPW)3 - LVDd3] + 0.6 g were obtained in three successive cardiac cycles.

The overall body surface area was calculated using Dubois' formula in order to calculate LVM index (LVMI): LVMI - LVM (grams) / body surface area (m^2).

In addition, left ventricular ejection fractions (LVEF) and left ventricular fractional shortening (LVFS) were estimated.

Values described by Devereux and collaborators, according to Lang *et al*[8]: LVMI>115 g/m^2 in males and>95 g/m^2 in women were considered LVH.

Relative left ventricular wall thickness (LVWT) was calculated by the following formula: LVWT 2 × LVPW/LVDd, and was considered normal <0.42 for both genders.

atients were classified into the following categories according to the left ventricular geometric pattern: normal, concentric remodeling, concentric LVH, and eccentric LVH[4,8].
- Normal: Normal LVMI (<115 g/m^2 for men and < 95 g/m^2 for women) and normal LVWT (< 0.42).
- Concentric remodeling: normal LVMI (<115 g/m^2 for men and < 95 g/m^2 for women) and increased LVWT (≥ 0.42).
- Eccentric hypertrophy: increased LVMI (>115 g/m^2 for men and ≥ 95 g/m^2 for women) and normal LVWT (< 0.42).
- Concentric hypertrophy: increased LVMI (≥ 115 g/m^2 for men and ≥ 95 g/m^2 for women) and increased LVWT (≥ 0.42).

Echocardiographic assessment of left ventricular diastolic function was performed by Doppler analysis for certain intracardiac flow patterns; pulsed tissue Doppler volume was placed at the level of the free edge of the mitral valve leaflets to measure: isovolumetric relaxation time, E wave deceleration time, and maximum E and A wave speed ratio (E/A), all of which allowed for diastolic function to be classified into:
- Normal: E wave (85 cm/sec), A wave (60 cm/sec), E/A ratio=1.5 and E wave deceleration time less than 200 msec.
- Prolonged relaxation: E wave velocity lower than A wave velocity (E/A <1) and prolonged deceleration time (greater than 200 msec).
- Pseudonormal: E wave velocity higher than A wave velocity, deceleration time (between 150 and 200 msec), E/A 1.0-1.5 and Color M-mode flow propagation velocity less than 45 cm/sec.
- Restrictive pattern: E wave velocity higher than A wave velocity, deceleration time less than 150 msec, E/A >1,5 and color M-mode propagation speed less than 45 cm/sec.

Ambulatory blood pressure monitoring

Ambulatory blood pressure monitoring was performed within one week after the echocardiogram and variables were obtained: Systolic/diastolic blood pressure average and loads at daytime, nighttime and 24 hours, and the presence of awake hypertension was identified. The circadian rhythm or dipper phenomenon was classified according to the decrease of average night SBP with respect to daytime SBP. Four patterns were obtained:
- Dippers: Nighttime SBP average decay between 10-20% compared to daytime SBP.
- Non-dippers: Nighttime SBP average decay between 0-9% compared to daytime SBP.
- Reverse dippers: Nighttime SBP average decay higher than daytime SBP average decay.
- Extreme dippers: Nighttime SBP average decay 20% higher than daytime SBP.

Statistical analysis

Descriptive analyses of sample characterization were carried out. Quantitative variables were summarized through arithmetic mean, standard deviation, and minimum and maximum values. For qualitative variables, absolute frequencies and their percentages were calculated.

We used the Chi-square test of independence to establish the associations between the variables. In all cases we worked with a 95% confidence interval, which corresponds to type I alpha error = 0.05.

RESULTS

All sociodemographic characteristics of the 54 hypertensive individuals included in the research are shown in **table 1**. A 59.3% of patients are white and 57.4% are women. Age ranged from 20 to 70 years for an average 55.4 years; 31.5% and 24.1% of patients were grouped in the age range from 46-55 and 56-65 years, respectively. Body mass index above the normal range was found in 72.2% (39 patients); 20 patients (37.0%) were overweight and 19 (35.2%) were obese. The rest of the subjects (27.8%) showed normal BMI.

Table 1. Sociodemographic characteristics in patients with high blood pressure. *Hospital «Calixto García»* 2016-2017 (n=54).

Demographic characteristics	Nº	%
Skin color		
White	32	59.3
Non-white	22	40.7
Sex		
Male	23	42.6
Female	31	57.4
Age groups (years)		
18 – 35	5	9.3
36 – 45	6	11.1
46 – 55	17	31.5
56 – 65	13	24.1
66 – 75	9	16.7
75 years and older	4	7.4
Body mass index		
Normal weight (18.5-24.9 kg/m^2)	15	27.8
Overweight (25.0-29.9 kg/m^2)	20	37.0
Obese (≥ 30.0 kg/m^2)	19	35.2

Table 2 summarizes the clinical characterization of HBP. According to its classification, 74.1% of patients were observed to have stage I hypertension and 25.9% stage II hypertension; 61% of patients were less than 5 years old and 29.6% were between 6 and 10 years old; 88.9% of patients received antihypertensive treatment and 42.6% used more than one drug for HBP control.

Table 2. Clinical characterization of patients with high blood pressure (n=54).

Clinical characteristics	Nº	%
HBP classification		
Stage I	40	74.1
Stage II	14	25.9
Progression time (years)		
Less than or equal to 5	33	61.1
Between 6 and 10	16	29.6
Between 11 and 15	1	1.9
More than 15	4	7.4
Antihypertensive treatment	4	7.4
None	6	11.1
Yes	48	88.9
- Polypharmacy	23	42.6

Ambulatory blood pressure monitoring

Mean SBP and DBP values obtained over the 24 hours were 124.9 mmHg and 71.2 mmHg; mean pulse pressure was 53.1 mmHg (**Table 3**); mean daytime and nighttime SBP/DBP were 127.3/73.6 mmHg and 120.1/66.1 mmHg, respectively; mean daytime SBP load was 35.9% and mean nighttime SBP load was 43.5%.

Twenty-one patients (38.9%) presented awake and nocturnal hypertension frequency was 51.9% (**Table 4**). According to nighttime SBP values with respect to daytime SBP values, a predominant non-dipper circadian profile was found (40.7%), followed by dipper (31.5%) and reverse dippers (25.9%).

Echocardiogram

Regarding the echocardiographic characteristics

Table 3. Blood pressure mean values and pressure loads by ambulatory blood pressure monitoring (n=54).

Ambulatory blood pressure monitoring	Blood pressure (mmHg)	
	Systolic	Systolic
Mean values		
24-hour period	124.9 ± 12.1	71.2 ± 8.9
Daytime	127.3 ± 11.6	73.6 ± 8.9
Nighttime	120.3 ± 14.9	66.1 ± 9.5
On awakening	128.6 ± 14.8	73.3 ± 10.7
Pulse pressure	53.1 ± 10.0	
Pressure loads	**Awake (%)**	**Asleep (%)**
Systolic blood pressure	35.9 ± 27.9	43.5 ± 35.9
Diastolic blood pressure	27.7 ± 28.8	21.8 ± 24.8
Both	20.7 ± 23.6	18.8 ± 24.1

Los valores expresan media ± desviación estándar

Table 4. Distribution of patients according to HBP patterns and circadian rhythm (n=54).

Parameters	Nº	%
Awake hypertension		
Yes	21	38,9
No	33	61,1
Nocturnal hypertension		
Yes	28	51,9
No	26	48,1
Circadian rhythm		
Dipper	17	31,5
Non-dippers	22	40,7
Reverse dippers	14	25,9
Extreme dippers	1	1,9

(**Table 5**), patients with nocturnal hypertension showed mean LVM (164.4 vs. 142.9 g) and LVMI (86.7 vs. 75.9 g/m^2) higher than those who did not, but without significant difference. A statistically significant difference was detected only in the interventricular septum measurement (11.1 vs. 9.6 mm; p<0.006) in favor of patients with nocturnal hypertension, where 11 patients (39.3%) with a septal thickness greater than 11 mm were found versus only 3 (11.5%) among those with normal nocturnal blood pressure values.

Tabla 6 shows a statistically significant relationship (p<0.001) between the abnormal circadian pattern and the presence of nocturnal hypertension. The rest of the variables showed no significant association, but 35 of the 54 patients (64.8%) were found to have left ventricular diastolic dysfunction: 34 (62.9%) type I and 1 (1.9%) type III. The predominant geometric pattern was normal (46.3%) followed by concentric remodeling (40.7%) and, to a lesser extent, concentric (7.4%) and eccentric (5.6%) hypertrophy.

When the relationship between both diastolic/geometric patterns with the presence or not of nocturnal hypertension was analyzed, independence tests were not valid due to the low frequency of patients with type III diastolic dysfunction and concentric/eccentric hypertrophy; so both categories merged respectively with type I dysfunction and concentric remodeling. In none of the cases a significant relationship with respect to the normal patterns was detected.

DISCUSSION

The sociodemographic variables of our research coincide with studies conducted both in Cuba and in other countries on subjects with HBP, reporting prevalence of female sex[10,11]. The highest prevalence observed in the age groups of 46 years and older corresponds to the behavior of this disease, as its prevalence has been found to increase with age, so that about 50% of the population over 70 years old is hypertensive; mainly with increased SBP. This corresponds to biological changes (increased peripheral resistances and reduced elasticity of vessels) that compromise the cardiovascular system as the person ages[12].

The high prevalence of overweight and obesity is seen from an anthropometric point of view coinciding with what was found by Camarena Navarro *et al*[13] in their ABPM study, where 37% of patients were obese.

This study showed a predominance of patients with short disease progression time (5 years or less); consistent with the findings of Linares Canovas *et al*[11] where more than half of patients (52%) were part of this group. Furthermore, it corresponds to the hypertension stage and applied treatment. Patients

Table 5. Echocardiographic characteristics of patients according to presence or not of nocturnal hypertension.

Echocardiographic characteristics	Nocturnal hypertension		p*
	Yes (n=28)	No (n=26)	
LV end-diastolic diameter (mm)	44.3±5.5	44.0±4.59	0.797
LV end-systolic diameter (mm)	29.0±5.2	28.5±4.4	0.753
Interventricular *septum* (mm)	11.1±2.2	9.6±1.4	**0.006**
LV posterior wall (mm)	9.9±2.4	9.6±1.3	0.532
RV wall thickness (mm)	0.4±0.1	0.4±0.0	0.603
LV ejection fraction (%)	63.6±5.4	64.5±8.2	0.637
Fractional shortening (%)	33.9±3.9	35.3±5.6	0.301
LV mass (g)	164.4±63.0	142.9±37.4	0.137
LV mass index (g/m^2)	86.7±24.9	75.9±16.7	0.072

* *Student t test*
LV, left ventricle; RV, right ventricle
Values express mean ± standard deviation

Table 6. Distribution of patients with or without nocturnal hypertension according to left ventricular diastolic-geometric patterns and circadian rhythm.

Parameters	Nocturnal hypertension		Total (n=54)	p (χ^2)
	Yes (n=28)	No (n=26)		
Circadian rhythm				
Dipper	3 (17.6%)	14 (82.4%)	17 (31.5%)	**0.001** (Normal vs. abnormal)
Non-dippers	13 (59.1%)	9 (40.9%)	22 (40.7%)	
Reverse dippers	12 (85.7%)	2 (14.3%)	14 (25.9%)	
Extreme dippers	0 (0%)	1 (100.0%)	1 (1.9%)	
LV Diastolic pattern				0.104 (Normal vs. disfunction)
Normal	7 (36.8%)	12 (63.2%)	19 (35.2%)	
Type I	20 (58.8%)	14 (41.2%)	34 (62.9%)	
Type III	1 (100.0%)	0 (0.0%)	1 (1.9%)	
LV Geometric pattern				0.571 (Normal vs. abnormal)
Normal	14 (56.0%)	11 (44.0%)	25 (46.3%)	
Concentric remodeling	9 (40.9%)	13 (59.1%)	22 (40.7%)	
Concentric hypertrophy	2 (50.0%)	2 (50.0%)	4 (7.4%)	
Eccentric hypertrophy	3 (100.0%)	0 (0.0%)	3 (5.6%)	

LV, left ventricle

who were not on drug treatment had stage I hypertension with short progression time. This is supported by clinical guidelines which state that, in the case of stage I hypertensive individuals and low total cardiovascular risk, drug treatment can be postponed for a few weeks and emphasize on healthy lifestyles[5,9].

Polypharmacy is common in the treatment of such patients, as evidenced in this research. In fact, data in the literature reviewed show that it may be higher. Camarena Navarro *et al*[13] found that, of patients with antihypertensive treatment, 84% were receiving combined treatment: 9 (43%) with association of two drugs, 6 (29%) with three drugs, and another 6 (29%) with four or more drugs.

Ambulatory blood pressure monitoring is currently the recommended test for the diagnosis and follow-up of HBP patients; which allows to evaluate not only day–night blood pressure variations, but also other parameters such as pulse pressure and dipper[14]. Camarena Navarro *et al*[13] showed that mean blood pressure values obtained during the 24 hours were 130/76 mmHg, while mean daytime blood pressure was 134/92 mmHg. In both cases the values exceed those found in this research. However, nighttime blood pressure, despite being a little elevated, was similar; although diastolic blood pressure was slightly higher. This fact is influenced by the number of patients with nocturnal hypertension observed in the current study.

The non-dipper profile predominated in our research sample. Sierra *et al*[15] in their ABPM study to 31.530 patients yielded similar results. These researchers described that the sum of the non-dipper and reverse dipper profiles (40.2% and 13.4%, respectively) appeared in more than half of patients and was associated with higher cardiovascular risk groups.

Generally, mean echocardiographic variables behaved within the reference range of normal values. However, the size of the interventricular septum was slightly increased, making a statistically significant difference in favor of the nocturnal hypertension-group. Although no statistically significant differences were found, we should note that both LVM and LVMI were slightly higher in the group of patients with nocturnal hypertension, with no differences in wall thickness between hypertensive groups. Specifically, the individual increase in myocyte size leads to an increase in weight and size of the organ. In addition, the increase in MVI is the basic parameter that determines whether there is LVH, that also corresponds to the higher frequency of hypertrophy in that group, which – in turn – is one of the early consequences of uncontrolled HBP[3].

Madariaga and Donis[16] reported that uncontrolled hypertensive patients had higher prevalence of abnormal geometry (61.7 vs. 38.3%; $p<0.01$), compared to controlled patients. In addition, concentric hypertrophy was the pattern associated with poor HBP control ($p<0.032$). Moreover, the high prevalence of left ventricular diastolic dysfunction in hypertensive patients revealed in this study is within the range between 62-79.1% described in the literature for hypertensive patients. However, it is slightly lower than the 68% reported by Oladimeji *et al*[17].

With regard to left ventricular geometry the results of this research differ from what was reported by Camarena Navarro *et al*[13], where 34% (30 patients) had LVH; but partially match the results of Madariaga and Donis[16], as these authors described a higher prevalence (84%) of abnormal left ventricular geometry and concentric LVH was the most prevalent pattern (47%), followed by concentric remodeling (22.9%) and eccentric LVH (14%).

The echocardiographic findings presented in this study indicate the need for future research on the cardiovascular system, preferably with larger samples, since –with increased life expectancy – HBP has become more frequent in medical practice and modulation of changes in different organs and functions of the body, associated with the aging process[18].

The main limitation of our research may be the cross-sectional design for obtaining the data, because only one 24-hour blood pressure measurement was made. Changes in the circadian rhythm may occur if measurements are repeated on another day.

Since abnormal left ventricular geometric patterns are highly prevalent and important for stratifying cardiovascular risk in hypertensive individuals, antihypertensive therapy guided by echocardiographic information on the anatomo-functional characteristics of the left ventricle should be evaluated to verify its impact on the prevalence of geometric abnormalities and cardiovascular risk in hypertensive patients.

CONCLUSIONS

Female white patients, aged 46-65 years, overweight/obese, and mild high blood pressure with short progression time predominated. Nocturnal hypertension was slightly elevated with predominant circadian rhythm alteration in non-dipper patients.

Editor's note

Dipper/non-dipper patient: if we say "patients with/without physiological nocturnal decrease in blood pressure (it must be greater than 10%)", we would also be referring to this type of patient. After considering that there is no any specific term that defines this Anglicism in Spanish, CorSalud decides keeping this term in its original language –since it did not reach a consensus between linguists and cardiologists–, because using **diper** (Hispanicized) can generate confusion when indexing this scientific article.

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