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Original research

ELECTROCARDIOGRAPHIC LEFT VENTICULAR HYPERTROPHY CRITERIA AND AMBULATORY BLOOD PRESSURE MONITORING PARAMETERS IN HYPERTENSION

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ABSTRACT

Background: *Left ventricular hypertrophy in hypertensive patients is an early complication, related to blood pressure control and the appearance of arrhythmias, especially atrial fibrillation, once it appears, the patient has been stratified to a high cardiovascular risk. 24 - hour ambulatory blood pressure predicted cardiovascular risk and target organ damage stronger than office blood pressure. However, in Vietnam, there are not many assessment of left ventricular hypertrophy detected on electrocardiogram. Therefore, we conducted our study, studying left ventricular hypertrophy on electrocardiogram and some parameters of 24-hour ambulatory blood pressure in hypertensive patients.*

Methods: *101 patients admitted to the Department of Cardiology, Hue Central Hospital, diagnosed with hypertension according to the Vietnam Society of Hypertension 2022 and previously treated for hypertension. Electrocardiogram and 24-hour ambulatory blood pressure monitoring were performed. The study method was a cross-sectional descriptive study with comparison.*

Results: *In the hypertensive group with/without left ventricular hypertrophy on electrocardiogram, the rate of morning surge was 73.33% vs. 46.48% ($p < 0.05$). Hypertension with morning surge increased the risk of left ventricular hypertrophy on electrocardiogram by 3.17 times compared with hypertension without morning surge ($p < 0.05$) and increased the risk of increased Sokolow - Lyon voltage index on electrocardiogram by 9.03 times ($p < 0.05$). There was a weak positive correlation between 24-hour mean SBP and day mean SBP with the Cornell index and the Gubner-Ungerleider index with $p < 0.05$. There was a weak positive correlation between the Cornell index and the Gubner-Ungerleider index with $p < 0.05$. There was a weak positive correlation between the night-time mean SBP and night-time mean DBP with the Cornell index with $p < 0.05$.*

Conclusion: *24 - hour ambulatory blood pressure parameters predict the appearance of left ventricular hypertrophy detected on electrocardiogram, as well as provide information to treat hypertension.*

Keywords: *Hypertension, left ventricular hypertrophy detected on electrocardiogram, 24 - hour ambulatory blood pressure monitoring.*

I. INTRODUCTION

In Vietnam, hypertension and atherosclerotic cardiovascular diseases are becoming important public health problems. This is partly due to changes in diet and lifestyle along with the country's economic development. The incidence of hypertension in Vietnam is increasing, so the Vietnamese Ministry of Health has included hypertension in the program for prevention of non-communicable diseases [1]. Although complications on target organs caused by hypertension are severe, an epidemiological survey in Vietnam (2002 - 2008)

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conducted on 9832 people ≥ 25 years old showed that 25,1% of the population had hypertension, nearly half of whom did not know they had the disease; the treatment rate in hypertensive patients was 62%, of which 38.3% of hypertension was controlled [2]. Vietnam Society of Hypertension - Vietnam National Heart Association (VSH/VNHA) on diagnosis and treatment of hypertension 2022, the International Society of Hypertension 2020, the European Society of Cardiology/European Society of Hypertension (ESC/ESH) 2023 have proposed blood pressure benchmarks based on current blood pressure measurement methods to diagnose hypertension and these blood pressure values are used for people aged 18 and over [3-5].

Electrocardiogram: Is a test with reasonable cost and easy to perform, recommended as the first step in detecting left ventricular hypertrophy in current voltage criteria (Cornel criteria, Sokolov Lyon), Romhilt-Estes score. Regardless of the criteria used, the sensitivity of electrocardiogram in detecting left ventricular hypertrophy is about 50-60%, but the specificity is up to 85-90%. In addition, detect other abnormalities such as atrial fibrillation... [6-9].

Echocardiography: Currently, there are many methods of echocardiography performed such as 2D, 3D echocardiography. It is more sensitive than electrocardiography in detecting left ventricular hypertrophy and is the gold standard in assessing changes in left ventricular structure and function. However, it is limited by cost and requires a specialist to perform [4, 6, 9, 10].

Cardiac magnetic resonance: Proposed as the non-invasive "new gold standard" in assessing left ventricular hypertrophy, differentiate types of left ventricular hypertrophy (hypertension, hypertrophic cardiomyopathy, infiltrative cardiomyopathy...). But limited by availability and high cost [6, 9, 10].

Left ventricular remodeling in hypertension is a process of changes in myocardial fibers (hypertrophy, thickening, shortening) and an increase in non-myocardial components (vasculature, collagen fibers, endothelial cells, fibroblasts, immune system), resulting in left ventricular hypertrophy, commonly known as concentric left ventricular hypertrophy [6, 10, 11]. Non - cardiomyocytes are also respond to increased cardiac load, neurohumoral and inflammatory systems. This leads to increased accumulation of these components in the left ventrical mass, consist of connective tissue cells and a network of structural proteins, called the extracellular matrix (ECM), mainly collagen types I and III, and elastin. The function of the ECM is to support and guide the aligned cellular structures (cardiomyocytes, capillaries, lymphatic vessels). By preventing the myocardial fibers and extracellular structures from sliding away from each other, the muscle fibers generate the force of contraction that is transmitted into the ventricular chamber [9, 10].

Despite its low sensitivity and specificity in diagnosing left ventricular hypertrophy, the use of electrocardiography has been shown to be a valuable diagnostic test for cardiovascular disease. In the ALLHAT (Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack) study, left ventricular hypertrophy determined by the initial Cornell voltage criteria was independently associated with increased cardiovascular mortality and all-cause mortality during 5 years of follow-up in treated hypertensive patients [12]. In the LIFE (Losartan Intervention for Endpoint Reduction) study, persistent or progressive left ventricular hypertrophy detected by the integrated Cornell and Sokolow-Lyon criteria was associated with increased all-cause mortality [13].

II. MATERIALS AND METHODS

2.1. Subject

We conducted a study on 101 in-hospital hypertensive patients at Hue Central Hospital. Sampling was done by convenience method. Criteria for diagnosing hypertension according to blood pressure levels measured at the clinic. Diagnosis of hypertension and classification according to VNHA recommendations in 2022. Patients with a history diagnosed with hypertension and taking medication were also included in the study [3].

2.2. Methods

Cross-sectional studies. Ambulatory blood pressure monitoring. Assessment of left ventricular hypertrophy by 12-lead electrocardiogram using left ventricular hypertrophy assessment criteria: Sokolow-Lyon voltage, Cornell voltage, Gubner-Engerleider voltage, Lewis voltage criteria, Sokolow-Lyon

product, Cornell product, Gubner-Ungerleider product, Romhilt-Estes score [7, 10, 14].

Morning surge: SBP and DBP increase by at least 20/15mmHg from the lowest BP during sleep to the average of the first 2 hours after waking up [15, 16].

III. RESULTS

Among the 101 patients participating in the study, the majority of hypertensive patients were treated with 1 regimen at a rate of 35.64%, the most commonly regimen was ACEi/ARB at a rate of 54.46%. The rate of patients who oblivious the type of drug they were taking was 24.75% (Table 1). Patients with office heart rate > 80 beats/minute in the left ventricular hypertrophy group were statistically significantly higher, 76.67% and 52.11% with p < 0105 (Table 2). Morning surge in the left ventricular hypertrophy group were statistically significantly higher, 73.33% and 46.48% with p < 0.05 (Table 3).

Table 1: Characteristics of treatment antihypertensive drug of the study subjects.

Pharmacological treatment	n	%
1 regimen	36	35.64
2 regimens	32	31.68
≥ 3 regimens	8	7.92
ACEi/ARB	55	54.46
BB	23	22.77
CCB	29	28.71
Diuretic	22	21.78
MRA	7	6.93
Statin	31	30.69
Oblivious	25	24.75

Table 2: Distribution of risk factors according to left ventricular hypertrophy group on electrocardiogram.

Risk factor	LVH (n = 30) (n,%)		Non-LVH (n = 71) (n,%)		p
	(n)	(%)	(n)	(%)	
Age ≥ 65	15	50.00	41	57.75	0.474
Male	12	40.00	29	40.85	0.937
Office heart rate > 80 beats/minute	23	76.67	37	52.11	0.022
Overweight/obese	11	36.67	27	38.03	0.897
Diabetes	4	13.33	10	14.08	0.920
High LDL-C/Triglycerid	21	70.00	55	77.46	0.427
Smoke	2	6.67	1	1.41	0.155

Table 3: Evaluation of the expression of parameters through 24 - hour ambulatory blood pressure in groups with and without left ventricular hypertrophy detected on electrocardiogram.

Parameters		LVH (n = 30)		Non-LVH (n = 71)		p
		(n)	(%)	(n)	(%)	
Overload SBP 24-hours		16	53.33	26	36.62	0.119
Overload DBP 24-hours		15	50.00	24	33.80	0.127
Morning surge		22	73.33	33	46.48	0.013
Morning hypertension		21	70.00	49	69.01	0.922
Dipper	Yes	6	20.00	18	25.35	0.564
	No	24	80.00	53	74.65	

Hypertension with morning surge increased the risk of LVH on electrocardiogram by 3.17 times compared with hypertension without morning surge, $p < 0.05$ (Table 4). Hypertension with morning surge increased the risk of increased Sokolow-Lyon index on electrocardiogram by 9.03 times compared with hypertension without morning surge, $p < 0.05$ (Table 5). Rate of LVH-echocardiography higher than LVH-electrocardiography, 33.66% and 29.7% > but not statistically significantly, $p > 0.05$ (Table 6).

Table 4: Association between morning surge and LVH on electrocardiogram.

Parameter		LVH		OR (95% CL)	p
		Yes	No		
Morning surge	Yes	22 (21.78%)	33 (32.67%)	3.17 (1.24 - 8.06)	0.013
	No	8 (7.92%)	38 (37.62%)		

Table 5: Association between morning surge and LVH index on electrocardiogram.

		Morning surge		OR (95% CL)	p
		Yes	No		
Sokolow Lyon	Increased	16 (15.84%)	2 (1.98%)	9.03 (1.95 - 41.76)	0.001
	Non-increased	39 (38.61%)	44 (43.56%)		
Sokolow product	Increased	6 (5.94%)	1 (0.99%)	5.51 (0.64 - 47.56)	0.122
	Non-increased	49 (48.51%)	45 (44.55%)		
Cornell	Increased	8 (7.92%)	3 (2.97%)	2.44 (0.61 - 9.79)	0.337
	Non-increased	47 (46.53%)	43 (42.57%)		
Cornell product	Increased	4 (3.96%)	1 (0.99%)	3.53 (0.38 - 32.75)	0.373
	Non-increased	51 (50.50%)	45 (44.55%)		
Gubner-Ungerleider	Increased	4 (3.96%)	1 (0.99%)	3.53 (0.38 - 32.75)	0.373
	Non-increased	51 (50.50%)	45 (44.55%)		
Gubner-Ungerleider product	Increased	5 (4.95%)	0 (0%)	0.52 (0.43 - 0.63)	0.061
	Non-increased	50 (49.50%)	46 (45.54%)		
Lewis	Increased	7 (6.93%)	0 (0%)	0.51 (0.42 - 0.62)	0.015
	Non-increased	48 (47.52%)	46 (45.54%)		
Rhomit-Ester	Increased	9 (8.91%)	5 (4.95%)	1.60 (0.50 - 5.18)	0.426
	Non-increased	46 (45.54%)	41 (40.59%)		

Table 6: Comparison of LVH on electrocardiogram and echocardiography.

Feature	Electrocardiogram		Echocardiography		p
	n	%	n	%	
LVH	30	29.70	34	33.66	0.333
Non-LVH	71	70.30	67	66.34	

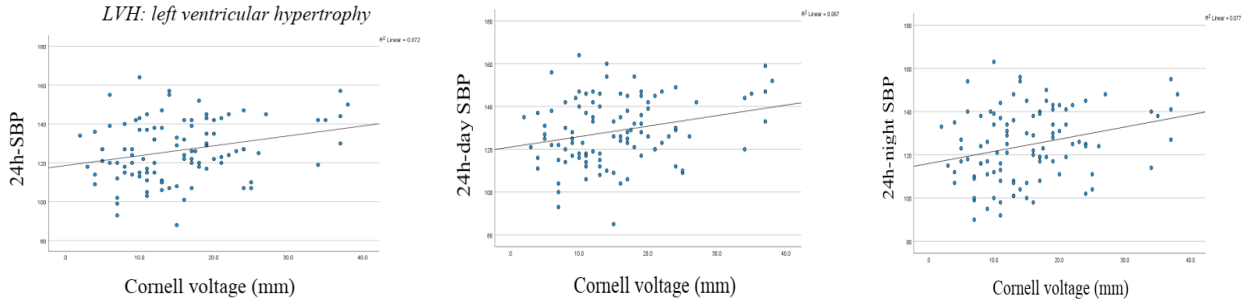

Figure 1: Correlation between Cornell index and 24 - hour SBP, y = 0.51x + 118.60, with x is voltage Cornell index ($p < 0.05$); between Cornell index and day - SBP, y = 0.49x + 121.00, with x is voltage Cornell index ($p < 0.05$); Cornell index and night - SBP, y = 0.35x + 66.80, with x is voltage Cornell index ($p < 0.05$).

IV. DISCUSSION

4.1. Risk factor characteristics between the two groups with and without left ventricular hypertrophy detected on electrocardiogram.

Our study was conducted on 101 participants with an average age of 68.74 ± 13.36. Based on electrocardiogram, left ventricular hypertrophy was detected in 29.70%. There was no difference between men and women, 11.88% and 17.82% with $p > 0.05$. Office heart rate > 80 beats/minute in the left ventricular hypertrophy group was statistically higher than in the non-left ventricular hypertrophy group, 76.67% and 52.11% with $p < 0.05$, table 1. In which other risk factors including age over 65, male, overweight/obesity, diabetes, increased LDL-C/Triglyceride, smoking were not significantly different ($p > 0.05$). Echocardiography detected left ventricular hypertrophy at a rate of 33.66%, higher than using electrocardiogram at 29.70%, but there was no statistically significant difference with $p > 0.05$. When based on echocardiography, the detection rate of left ventricular hypertrophy in men and women was 12.87% and 20.79%, respectively, with no statistically significant difference with $p > 0.05$.

4.2. Correlation between left ventricular hypertrophy detected on electrocardiogram and 24 - hour ambulatory blood pressure parameters.

Hypertension with morning surge increased the risk of left ventricular hypertrophy on electrocardiogram by 3.17 times ($p < 0.05$) table 4, increased the risk of increased Sokolow-Lyon index on electrocardiogram by 9.03 times ($p < 0.05$) (Table 5).

Analyzing other ambulatory blood pressure parameters in subjects with left ventricular hypertrophy on electrocardiogram, we did not record statistically significant differences between the two groups with and without left ventricular hypertrophy detected on electrocardiogram. Such as morning hypertension, dipping blood pressure, non-dipping blood pressure, 24 - hour systolic and diastolic blood pressure overload ($p > 0.05$).

There was a weak positive correlation between 24 - hour systolic blood pressure and the Cornell index and the Gubner - Ungerleider index ($p < 0.05$). There was a weak positive correlation between day-systolic blood pressure and the Cornell index and the Gubner-Ungerleider index ($p < 0.05$). There was a weak positive correlation between nighttime-systolic blood pressure and the Cornell index ($p < 0.05$). There was a weak positive correlation between nighttime-díatoliic blood pressure and the Cornell index ($p < 0.05$) (Figure 1).

A study by Gómez-Marcos et al. in 2014 showed that 24-hour ambulatory systolic blood pressure has the best prognosis in patients with left ventricular hypertrophy detected on electrocardiogram in adults. The percentage of time with daytime systolic blood pressure ≥ 135 mmHg and nighttime systolic blood pressure ≥ 120 mmHg affects the occurrence and progression of left ventricular hypertrophy [7]. Similarly, in our study, it was also noted that the average 24 - hour systolic blood pressure and the average daily systolic blood pressure were positively correlated with left ventricular hypertrophy determined by the Cornell voltage criteria and the Gubner - Ungerleider voltage criteria, especially when in our study, there was also a correlation with the average nighttime systolic blood pressure ($p < 0.05$) (Figure 1).

Other 24 - hour ambulatory blood pressure parameters that are often analyzed are dipping/ non-dipping nighttime blood pressure. In 2004, a study by Cuspidi et al. noted that there was a statistically significant difference in the group of patients with left ventricular hypertrophy detected by echocardiography through the index of diastolic interventricular septal thickness ($p < 0.05$), left ventricular mass ($p < 0.01$), and left ventricular mass index ($p < 0.01$) compared with the group with dipping and non-dipping blood pressure. The left ventricular mass index was more strongly related to 48 - hour nighttime blood pressure than to daytime blood pressure (nighttime SBP, $r = 0.2$, $p < 0.0001$; nighttime DBP, $r = 0.15$, $p < 0.003$; day SBP, $r = 0.16$, $p < 0.001$; day DBP, $r = 0.09$, $p < 0.06$) [17]. In our study, there was no statistically significant association between non-dipping blood pressure and left ventricular hypertrophy ($p > 0.05$). This may be due to the sample size and hypertensive patients were treated with ACE inhibitors and angiotensin II receptor blockers, which are drugs that have been shown to have the ability to prevent adverse remodeling of the heart and blood vessels.

Another 24 - hour ambulatory blood pressure index we studied was morning surge. There was a statistically significant difference between the groups with/without left ventricular hypertrophy detected on electrocardiogram (73.33% and 46.48%, respectively, $p < 0.05$), (Table 1). However, it is also necessary to note some issues that affect the quality of 24 - hour ambulatory blood pressure measurements as well as the effects on the patient's sleep quality such as lying position, environmental changes, movement, depth and quality of sleep [15, 16].

Studying the regression of left ventricular hypertrophy in hypertensive patients by Marcus et al. 2007, on 104 patients with hypertension for more than 1 year, without coronary artery disease. Monitored 24-hour electrocardiogram and echocardiogram at the time of the study and after 24 months. Divided into two groups, the group with regression of left ventricular hypertrophy (53.8%) was evaluated by left ventricular hypertrophy mass index (154.9 ± 5.1 with 123.5 ± 2.8 g/m^2), the group with progression of left ventricular hypertrophy (45.2%) (122.2 ± 3.2 with 143.2 ± 3.2 g/m^2). The results showed that the group with regression of left ventricular hypertrophy reduced the frequency of atrial fibrillation from 12.5% to 1.8% with $p < 0.05$, while the group with progression of left ventricular hypertrophy increased from 8.5% to 17.0% [18].

In 2013, Cao Truong Sinh and Huynh Van Minh showed that most patients with hypertension had morning surge (57.9% - 81 patients) and morning hypertension (74.3% - 104 patients). The rate of morning surge in grade III hypertension was significantly higher than in grade I and grade II. The rate of morning hypertension in grade II and grade III hypertension was higher than in grade I. The rate of morning surge was higher than that without this phenomenon ($p = 0.008$). This shows that morning surge and morning hypertension are common phenomena in cerebrovascular accidents with hypertension [16].

V. CONCLUSION

Our study shows that hypertensive subjects with morning surge are associated with the appearance of left ventricular hypertrophy detected on electrocardiogram. In particular, it increases the risk of left ventricular hypertrophy detected by Sokolow - Lyon criteria by 9.03 times. Showing the potential for widespread use of ambulatory blood pressure for diagnosing and monitoring early complications of hypertension. More studies are needed to evaluate the regression of left ventricular hypertrophy detected on electrocariogram in the treatment of hypertension.

Disclosure

The authors report no other conflicts of interest in this work.

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