Abnormal Blood Pressure Load by Ambulatory Blood Pressure Monitor as a Predictor for Left Ventricular Hypertrophy in Hypertensive Patients.

حمل ضغط الدم بجهاز قياس ضغط الدم المحمول كدليل لتثخن جدران القلب في المرضى المصابين بارتفاع ضغط الدم الشرياني.

Dr.AbdulhamzaRajoojHmood, FICMS (internal medicine)، College of Medicine, Kerbela University.

Dr. LaithAbdulhusseinAldabbagh,FICMS (internal medicine), College of medicine, Kufa University.

Laitha.aldabbagh@uokufa.edu.iq

الخلاصة

الهدف: يعتبر فحص القلب بجهاز الايكو من الفحوصات المهمة لتشخيص تثخن جدران القلب نتيجة ارتفاع ضغط الدم وذلك لوجود علاقة وثيقة بين تثخن جدار القلب وارتفاع ضغط الدم. في هذه الدراسة تمت المقارنة بين جهاز الضغط المحمول وجهاز الايكو لتشخيص تثخن الجدران.

المنهجية: تم بحث 53 شخص مصاب بارتفاع ضغط الدم باستخدام تخطيط القلب الكهربائي وعمل فحص ايكو القلب لدراسة كتلة البطين اليسر ومقارنتها بحمل ضغط الدم بجهاز قياس ضغط الدم المحمول.

النتائج: تم تشخيص 31 مريضا لديهم تثخن في جدران القلب. معظمهم كانوا ذكورا وفترة ارتفاع ضغط الدم كانت طويلة. النسبة الإحصائية كانت وثيقة بين تثخن الجدران ومعدل الضغط العالي والواطئ وكانت أيضا وثيقة بين تثخن الجدران وحمل الضغط الذي تم قياسه عن طريق جهاز الضغط المحمول.

الاستنتاجات: جهاز الضغط المحمول كان دقيقا في تشخيص تثخن جدران القلب مقارنةبجهاز الايكو. حمل الضغط كان لديه حساسية عالية جدا في التشخيص وخصوصية مقبولة. بالإمكانأيضا استبعاد إمكانية وجود تثخن في جدران القلب لدى المرضى اللذين يكون حمل الضغط لديهم طبيعي.

التوصيات: يجب على جميع المرضى المصابين بارتفاع ضغط الدم أن يتم إحالتهم لغرض الفحص باستخدام جهاز الضغط المحمول خصوصا اذا كانوا ذكورا ولديهم المرض منذ فترة طويلة.

مفردات البحث: جهاز الضغط المحمول، ارتفاع ضغط الدم، جهاز الايكو، تثخن جدران القلب

Abstract

Aim: The aim of this study is to assess the accuracy of ambulatory blood pressure load as a predictor for LVH in comparison with echo in hypertensive patients.

Methods: We report ECG, echo study, and then ABPM findings in 53 individuals during 1 year. All of the referred subjects were hypertensive with variable socio-demographic characteristics.

Results: We found 31 patients having LVH on echo study; most of them were male and significantly correlated with duration of hypertension, average 24-hours SBP and DBP, mean day-time and mean night-time SBP and DBP, and with the circadian rhythm. The association between LVH and BP load was also significant.

Discussion: Echo was more sensitive than ECG in detecting LVH and ABPM was rather more sensitive than echo. The study had found that BP load measurement had very high sensitivity with an acceptable specificity and an excellent negative predictive value in rolling out LVH. The association between LVH and parameters of ABPM was also significant.

Conclusions: Abnormalities on ABPM are very common in hypertensives and are strongly indicated to identify the BP profile.

Recommendations: ABPM was more sensitive than ECG and echo study in the detection of LVH. Echo, on the other hand is rather more sensitive than ECG for the same purpose.Male hypertensive should be offered an ABPM at every opportunity for early detection of LVH.

Key words: ABPM; ambulatory blood pressure monitor, BP; blood pressure, echo; echocardiography, LV; left ventricle, LVH, left ventricular hypertrophy.

INTRODUCTION

Hypertensive heart disease is a leading cause of morbidity and mortality in patients with hypertension [(1)]. Long-lasting systemic arterial hypertension increases left ventricular wall stress leading to activation of various neuro-hormonal mechanisms with the expression of genes regulating structural remodeling of myocardium and extra cellular matrix resulting in increase in left ventricular mass and setting the stage for progression of systolic and diastolic dysfunction [(2)].

In advanced stages the remodeling process causes organ damage and poses an elevated risk of cardiovascular events [3].

Although any type of LVH increases the incidence of cardiovascular disease, the concentric type of left ventricular hypertrophy has been identified as the cardiac structural parameter that is most strongly related with cardiovascular risk [4, 5].

The relationship between clinic blood pressure and LVH is well known, but there is a body of evidence to suggest that this correlation is stronger for blood pressure measured in ambulatory conditions. ABPM is non-invasive, easily reproducible, portable, accurate and affordable. Yet for reasons not clearly understood, it remains underutilized in clinical practice [6]. Similarly, the regression of LVH associated with improved cardiovascular prognosis may be more closely correlated with reductions in ambulatory BP than office blood pressure [6, 7].

Twenty-four ambulatory blood pressure monitoring (24-ABPM) values of average systolic pressure, unlike office measurements, correlate with LVH indices in hypertensive subjects. The data also suggest that early structural cardiac changes such as an increase in septal thickness and a decrease in LV ejection time are related to ambulatory blood pressure profile. However, there are conflicting data regarding the relationship between the circadian rhythm of BP, especially non-dipping nocturnal BP, and LVH and left ventricular diastolic function in patients with essential hypertension[8].The aim of this study is to assess the accuracy of ambulatory blood pressure load as a predictor for LVH in comparison with echo in hypertensive patients.

PATIENTS AND METHODS

In this cross sectional study, consecutive known hypertensive patients (n=53) were recruited from inpatient ward and outpatient internal medicine clinic in AL-Hussein medical city and studied by ABPM during the period from February 2013 to February 2014. Inclusion criteria were well-controlled hypertension with preserved left ventricular ejection fraction (EF ≥ 50%) and exclusion criteria were:

1. Severe hypertension (SBP ≥ 210 mm Hg and/or DBP ≥ 115 mm Hg).
2. Significant chronic kidney disease.
3. Valvular heart disease.
4. Heart failure.
5. History of ischemic heart disease.
6. Atheletic.

<u>Transthoracic Echo</u>

Transthoracic echo examination was performed with mindray DC 7 with measurements of chamber dimensions taken from two-dimensional M-mode and calculation of LV mass. Linear measurements were made according to the European Society of Echocardiography [9]. Left ventricle volumes used to estimate ejection fraction (EF) were determined using the modified biplane Simpson’s method. Left ventricular mass was calculated according to the American Society of Echocardiography (ASE) recommendation and as follows:

LV Mass = [(LVED + VST + PWT) ^{3}– LVED^3] X 1.05 g/cm$^{\mathbf{3}}$ where LVED; left ventricular end-diastolic diameter, VST; Ventricular septum thickness, and PWT; Posterior wall thickness.

The left ventricular mass index was obtained as an indicator of LVH by echo as a ratio of left ventricular mass and body surface area. [10]

Table1: Left ventricular hypertrophy grading.

	Borderline	Moderate	Severe
women			
LV mass/BSA (g/m^2)	96–108	109–121	≥122

Men			
LV mass/BSA (g/m^2)	116–131	132–148	≥149

Table 1 shows that the grade of the LVH according to the LV mass in both gender.

Ambulatory BP Monitoring

ABPM was used to subjects with an elevated office BP ≥140 mm Hg systolic and/or ≥90 mm Hg diastolic. Using of the commercially available ContacTM device (Fig. 1-1), ABPM is performed with the patient wearing a portable BP measuring device, on the non-dominant arm or the arm with the highest blood pressure, for continuous 24 hours period so that it gives information on BP during daily activities and at night during sleep[11].

At the time of fitting of the portable device, the difference between the initial values and those from office BP measurements were not greater than 5 mmHg. In the event of a larger BP difference the ABPM cuff was removed and fitted again.

Figure 1.1 Contac ambulatory Blood Pressure Monitor Device.

The patient is instructed to engage in normal activities but to refrain from strenuous exercise and, at the time of cuff inflation, to stop moving and talking when possible and to keep the arm still with the cuff at the heart level. Each participant was given a diary and was asked to provide information on symptoms and events that may influence BP, in addition to the time of any drug ingestion, meals, and going to- and rising from the bed. Measurements are often made at 15 minutes intervals during the day and every 30 minutes overnight [12].

Quality of the ABPM studies was defined by the length of time that the monitor was actually worn and the number of successful BP recordings. Monitors worn for ≥ 21 hours with ≥18 hours with ≥ 1 valid BP measured per hour were acceptable for analysis. As additional criteria to ensure adequate representation of both wake and sleep periods, each ABPM had to have ≥1 successful BP recording in ≥75% of wake hours and ≥75% in sleep hours. The monitory was repeated in case that less than 75 % of BP during day time and night time periods was not satisfactory [13].

Analysis of ABPM was undertaken according the standardized protocol of blood pressure profile (average 24-hours, average day-time, and average night time), maximum values, blood pressure load, and circadian rhythm.

ABP profile was interpreted in relation to dairy information taking into account the following normal values [14]:

Average ABP over 24-hours period < 130 / 80 mmHg

Average day-time ABP < 135 / 85 mmHg

Average night-time ABP < 120 / 75 mmHg

Wake and sleep BP loads were calculated as the percentage of readings ≥ 95th percentile which in adults corresponds to < 20% above normal values. For 24-hour load calculation, a weighted sum of wake and sleep loads was used [(15)].
Mean day time and night time (sleep) ABP measurements were considered normal when differ by 10 – 20%. Based on that, participants were classified into reverse dipper < 0, non- dipper < 10, dipper 10 – 20, and extreme dipper > 20 [(16)].

Other Variables

Renal indices and ECG was requested for all patients to detect renal impairment and LVH. A voltage criteria for left ventricular hypertrophy have been proposed on the basis of the presence of tall left precordial R waves and deep right precordial S waves [SV_1 + (RV_5 or RV_6) > 35 mm]. Repolarization abnormalities (ST depression with T-wave inversions, formerly called the left ventricular "strain" pattern) may also appear in leads with prominent R waves.

All statistical analyses were performed using SPSS version 20 software (SPSS Inc. Chicago, IL, USA). Categorical data were compared using chi-square tests. Student t test were used to compare numerical variables, respectively. Data were expressed as mean (standard deviation; SD), minimum-maximum and percent (%) where appropriate. $p < 0.05$ was considered statistically significant.

RESULTS

The range of patients' age underwent ABPM was 34–65 years with a mean age (± SD) of 51±9 years.

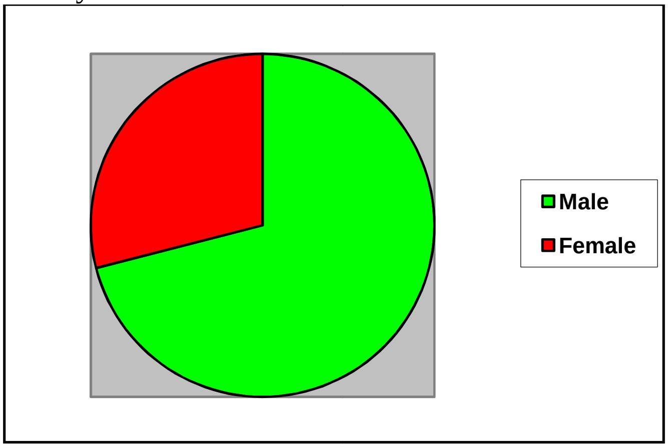

Figure 2: gender distribution of the studied patients.

The majority of the studied patients was male (n=38) and represented 71% while the remaining were female (n=15) and represented 29%.

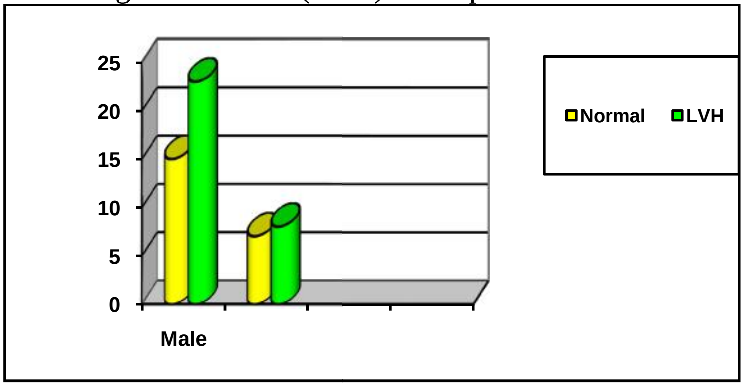

Figure 3: LVH distributions in the studied patients.

In our study (Figure 3) we had found 31 patients having LVH as measured by echo and distributed as 23 male and 8 female; the remaining 22 patients had normal LV mass and distributed as 15 male and 7 female.

Table2: LVH detection.

		Echo		Total
		Normal	LVH	
ECG	Normal	20	10	30
	LVH	2	21	23
Total		22	31	53
P value =0.0001				

Table 2 shows that Echo was more sensitive than ECG in the detection of LVH and the difference was statistically significant.

Table3: Association between gender distribution and LV mass.

LV mass (gm/m^2)	Gender		Total
	Male	Female	
80-100	14	10	24
101-120	4	0	4
121-150	20	5	25
Total	38	15	53

Table 3 shows that Increment in LV mass was mostly noticed in male (n=38) with a significant association between LVH and gender.

Table4: Association between LV mass and duration of hypertension.

	N	Mean	SD	Std. Error Mean
Duration of HTN	53	7.2830	5.4	0.7
LV Mass by echo	53	114.0755	22.3	3
(P value = 0.00001)				

Table 4 shows that there was a significant association between the duration of hypertension and the increment in left ventricular mass measured by echocardiography.

Table5: Association between LV mass and ABPM systolic and diastolic 24-hours blood pressure.

	N	Mean	SD	Std. Error Mean
LV mass by echo	53	114	22	3.06531
Average 24-hour SBP	53	134	10	1.38449
Average 24-hour DBP	53	78	8	1.14367
P value = 0.0001				

Table 5 shows that there was a significance association between the LV mass measured by echo and the average 24 hours systolic and diastolic blood pressure measured by ABPM.

Table6: Association between LV mass and the mean day time and night time systolic and diastolic blood pressure.

	N	Mean	SD	Std. Error Mean

LV mass	53	114	22	3
Mean day-time SBP	53	136	9	1
Mean night-time SBP	53	118	9	1
Mean day-time DBP	53	68	7	0.9
Mean night-time DBP	53	78	8	1
P value = 0.0001				

Table 6 shows that there was a significance association between the LV mass measured by echo and the mean day time and night time systolic and diastolic blood pressure measured by ABPM.

Table7: Night time BP pattern.

		Night BP pattern			Total
		Dipper	Non dipper	Reverse dipper	
LV mass	Normal	23	0	0	23
	LVH	18	7	5	30
Total		41	7	5	53

Table 7 shows that Patients who had normal LV mass on echo (n=23) showed exclusively dipper pattern on studying the BP profile during night. Patients with LVH (n=30) on echo were distributed as dipper (n=18), non-dipper (n=7), reverse dipper (n=5), and extreme dipper (n=0).

Table8: Association between the LV mass and the circadian rhythm.

		Circadian rhythm		Total
		Abnormal	Normal	
LV mass by echo	LVH	12	19	31
	Normal	0	22	22
Total		12	41	53
P value = 0.001				

Table 8 shows that there was a significant association between the LV mass measured by echocardiography and the circadian rhythm measured by ABPM.

Sensitivity of circadian rhythm on ABPM in comparison with LV mass measurement as a predictor for LVH = 12 / (12+0) X 100 % = 100%

Specificity of circadian rhythm on ABPM in comparison with LV mass measurement as a predictor for LVH = 22/ (19+22) X 100 % = 53 %

Negative predictive value for the circadian rhythm on ABPM = 22/ (0+22) X 100 % = 100 %

This demonstrate that the circadian rhythm on ABPM had very high sensitivity for detection of LVH with only moderate specificity and an almost excellent negative predictive value for rolling out LVH in the studied patients.

Table9: Association between LVH and BP load.

		BP load on ABPM		Total
		Abnormal	Normal	
LV mass by echo	LVH	23	7	30
	Normal	1	22	23

Total	24	24	29
P value = 0.0001			

Table 9 shows that patients who had normal LV mass on echo (n=23) showed that 1 patient having abnormal BP load and 22 patients with normal BP load while those who had LVH showed 23 patients with abnormal BP load and 7 patients were having normal BP load. The association between BP load and LVH was statistically significant.

The sensitivity of BP load in comparison with LV mass measurement as a predictor for LVH = 23 / (23+1) X 100 % = 95, 8 %. The specificity of BP load in comparison with LV mass measurement as a predictor for LVH = 22/ (7+22) X 100 % = 75, 8 %

Negative predictive value for the BP load on ABPM = 22/ (1+22) X 100 % = 95, 6 %. The likelihood ratio for positive test = 95, 8/ (1-75, 8) = 1, 28 and the likelihood ratio for negative test = (1-95, 8)/75, 8 =1, 25. This demonstrates that BP load measurement had very high sensitivity for detection of LVH with acceptable specificity and excellent negative predictive value for rolling out LVH in the studied patients.

DISCUSSION

Left ventricular hypertrophy is a strong predictor of cardiovascular morbidity and mortality in the general population, and particularly in patients with hypertension.

In our study, the range of patients' age was 34–65 years with a mean age (± SD) of 51±9 years. The majority of the studied patients was male (n=38) and represented 71% while the remaining were female (n=15) and represented 29%.

We had found 31 patients having LVH as measured by echo and distributed as 23 male and 8 female; the remaining 22 patients had normal LV mass and distributed as 15 male and 7 female. Echo was more sensitive than ECG in the detection of LVH and the difference was statistically significant. This was consistent with the recommendations of the U.S. preventive services task force in a study comparing the sensitivity of ECG versus echocardiogram and magnetic resonance image [(17)]. Increment in LV mass was mostly noticed in male (n=38) with a significant correlation between LVH and gender. This was consistent with Krumholz et al [(18)] who studied the sex differences in cardiac adaptation to isolated systolic hypertension. Furthermore, there was a significant association between the duration of hypertension and the increment in left ventricular mass measured by echo. This was with full agreement to Wierzbowska et al who studied the age-dependency of classic and new parameters of diastolic function [(19)].

Left ventricular mass measured by echo was significantly correlated with the increased average 24 hours blood pressure and with the increased mean day time and night time systolic and diastolic blood pressure measured by ABPM. Felicio et al suggest that higher nocturnal systolic BP (NSBP) levels might be responsible for an increased prevalence of LVH in hypertensive patients with type 2diabetes [(20)]. However, in another study which enrolled diabetic patients, echocardiographic structural alterations correlated more strongly with systolic BP means than with non-dipper/dipper BP ratio [(21)].

Patients who had normal LV mass on echo (n=23) showed exclusively dipper pattern on studying the BP profile during night. Patients with LVH (n=30) on echo were distributed as dipper (n=18), non-dipper (n=7), reverse dipper (n=5), and extreme dipper (n=0). There was a significant association between LV mass measured by echocardiography and the circadian rhythm measured by ABPM. Numerous studies have addressed the predictive value for cardiovascular risk of the night-time BP as documented by ambulatory monitoring [(22)]. There are several mechanisms that could be responsible for a lower fall of BP during sleep [(23)]. Also in another study published by Cuspidi et al. no differences in cardiac structure as well as prevalence of LVH were found in relationship to dipping or non-dipping status in the treated essential hypertensives with or without BP control. Cuspidi et al. concluded that a blunted reduction in nighttime blood pressure does not play a major role in the development of cardiovascular changes during the early phase of essential hypertension[24]. Balci et al. found that ventricular hypertrophy was higher in the nondipper group compared to the dipper group[25].

In addition, the findings of Stenehjem et al. suggest that the contribution of a blunted reduction in nocturnal BP to enlarged LV mass is significant and may play a pivotal role in the development of LVH, during the early phase of essential hypertension. Moreover, subjects in whom the nocturnal decrease in blood pressure is blunted (non-dippers) have been reported to have a greater prevalence of organ damage and a less favorable outcome [26]. A blunted fall in nocturnal BP also reflects the high level of cardiovascular risk in these patients. Nevertheless, in some studies the prognostic value of this phenomenon was lost when multivariate analysis included 24-h average blood pressure [5].

In our study, the circadian rhythm on ABPM had very high sensitivity for detection of LVH with only moderate specificity and an almost excellent negative predictive value for rolling out LVH in the studied patients.

Patients who had normal LV mass on echo (n=23) showed that 1 patient having abnormal BP load and 22 patients with normal BP load while those who had LVH showed 23 patients with abnormal BP load and 7 patients were having normal BP load (Table 9). The association between BP load and LVH was statistically significant. In our study, the BP load measurement had very high sensitivity for detection of LVH with acceptable specificity and excellent negative predictive value for rolling out LVH in the studied patients.

CONCLUSION:

1. ABPM is a sensitive tool to predict the LVH but moderately specific in comparison to echocardiography and is more sensitive than ECG in the detection of LVH.
2. BP load measured by ABPM has very high sensitivity for prediction of LVH with acceptable specificity and excellent negative predictive value for rolling out LVH in the studied patients.

RECOMMENDATIONS

1. Male hypertensives should be offered an ABPM at every opportunity for early detection of LVH.
2. All ABPM parameters should be measures as circadian rhythm has very high sensitivity for detection of LVH.

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