Validity of Echocardiographic parameters in the diagnosis of chronic effects of hypertension on the heart

Nu'man Salman Dawood Al-Nu'ami* M.Sc.

Summary:

J Fac Med Baghdad
2006; Vol. 48, No.2
Received May 2005
Accepted Jan . 2006

Background: *Hypertension causes compensatory left ventricle (LV) hypertrophy as a result of increased workload imposed on the heart, the LV is thickened and overall weight of the heart is increased*

Objectives: *Assess the validity of echocardiography (LV mass index in specific) as a criteria for the diagnosis of chronic effects of hypertension on the heart.*

Materials and methods: *fifteen patients with an established diagnosis of chronic hypertension and control group of another 15 subjects with no past history or current evidence of hypertension were included in the study sample. Echocardiographic variables were assessed.*

Results: *Among the 8 echocardiographic parameters assessed the LV mass index provided the best test for diagnosing chronic effects of hypertension. The optimal cut off value of LV mass index is 118.5(gm/m^2) at which the sensitivity is 66.7% and specificity 93.3%. In a clinical situation with equal odds of having asymptomatic hypertension, observing an LV mass index of 118.5(gm/m^2) or higher will establish the diagnosis of hypertension with 90.9% confidence.*

Conclusion: *The echocardiography (LV-mass index) was a good diagnostic tool for the undiscovered chronic hypertension.*

Keyword: *Echocardiography. , Hypertension. LV hypertrophy: Left Ventricle hypertrophy. LV mass index: Left Ventricle mass index.*

Introduction:

An increase of blood pressure in essential hypertension depends on a set of genes that tend to raise blood pressure[1], or it may result from atherosclerosis which is loss of elasticity or hardening of arteries. These effects cause an increase in the peripheral resistance of the vessels, which in turn cause an increased work of the heart, which results in hypertrophy of myocardial cells[2]. Hypertension causes compensatory LV hypertrophy as a result of increased workload imposed on the heart, the LV is thickened and overall weight of the heart is increased[3]. The clinical cardiac complication of persistently and abnormally elevated systemic blood pressure included increased LV mass, with or without chamber dilation, systolic and diastolic LV dysfunction, ventricular arrhythmias and sudden death[4].

The prevalence of silent myocardial ifarction (MI) is higher in hypertensive subject[5]. Also the mortality of hypertensive subjects is higher after initial MI[6]. The risk of major cardiovascular complications of hypertension is greater in hypertensive subjects with LV hypertrophy at echocardiography than in those with normal LV mass[7,8,9]. It seems logical from previous discussion that setting an optimum cut off value for LV mass to detect the chronic effects of hypertension is of concern for clinical practice.

* *Baghdad University, College of Medicine , Department of Physiology*

Left ventricle derived variables in echocardiography were :

Left ventricular mass LVM(gm) is given by equation (1) [10]

$$LVM = 0.80 \{ 1.04 [(LVSTd + LVIDd + LVPWTd)^3 - (LVIDd)^3] \} + 0.6 \quad ---(1)$$

Where : LVSTd , represent the LV septal thickness in diastole . LVIDd ,

Represent the LV internal diameter in diastole . LVPWTd , represent the LV posterior wall thickness in diastole .

Left ventricular mass normalized by the body surface area to obtain the LV mass index (gm / m^2) is given by equation (2) [11]

$$LVMI = LVM / BSA \quad -------------------------- (2)$$

Where BSA , is the body surface area (m^2) can be determined by formula of Dubois is given by equation (3) [12]

$$BSA\ (m^2) = (WKg^{0.425} * HCm^{0.725}) * 0.007184 \quad -------------------- (3)$$

Where W,H is the weight and height of subject .

Left ventricle wall stress :According to the Grossman equation is given by equation**(4)** [13]

$$LV\ wall\ stress(dyne/cm^2) = 0.334\ P(LVIDs) / LVPWTs*[1+LVPWTs / LVIDs] \quad --- (4)$$

Where : p, represents the systolic blood pressure . LVIDs , represents the Left ventricular internal diameter in systole . LVPWTs , represents The Left ventricular posterior wall thickness of left ventricle in systole .

Ejection fraction % , stroke volume(mL) and fractional shorting of left ventricle % are direct measurements.

The purpose of this study:

The present study assess the validity of echocardiography (LV mass index in specific) as a criteria for the diagnosis of chronic effects of hypertension.

Materials and Methods

Study sample

A total of thirty subjects were included in the study, fifteen patients with an established diagnosis of chronic hypertension and control group of fifteen subjects with no past history or current evidence of hypertension,age

was (40-55) year ,body weight was (60-85) kg and height was (1.6 – 1.8) meter were selected to be examined by tow –dimensional,pulsed Doppler echocardiography was performed commercially available ultrasound machine (VOLUSON 350A with 2.5 or 3.5 MHz,we recorded parameter with the ultrasound transducer guided by two-dimensional echocardiography imaging in a four-chamber view .This work was performed by the same qualified expert in echocardiographic unit in the AL-Yarmook Teaching Hospital

Statistical analysis

Data were translated into a computerized database structure. An expert statistical advice was sought for. Statistical analyses were compute assisted using SPSS ver 10 (Statistical Package for Social Sciences).

Frequency distribution for selected variables was done first. The statistical significance of difference in mean between 2 groups was done by t-test. Receiver operator characteristic (ROC) analysis was used to assess the validity parameters of a test with values measured on a continuous scale. P value less than the 0.05 level of significance was considered statistically significant.

Results

The results presented in this study were based on the analysis of 15 subjects with chronic hypertension and another group of 15 healthy control (normotensive) subjects.

As shown in table 1, the mean septal wall thickness in systole in the hypertensive group (14.5 mm) was obviously (although not significant statistically) higher than that of normotensive group (12.8 mm). Hypertension is associated with 13% increase in septal thickness in systole compared to normotensive controls. In diastole the spetal thickness was significantly higher(13.13 mm) than that of normotensive group (9.93 mm). Hypertension is associated with 32.2% increase in septal thickness in diastole compared to normotensive controls.

The mean LV mass was significantly higher among hypertensive group than normotensive subjects (249.4 $\pm$ 22 Vs 165.7 $\pm$ 10 gm). Hypertension is Associated with 50.5% increase in LV mass compared to normotensive controls, table 2. A trend similar to that observed for LV mass in normotensive and hypertensive was also applicable to LV mass index (90.4 $\pm$ 5.3 Vs 131.3 $\pm$ 10.6 gm/m^2), i.e. hypertension is associated with a 45.3% increase in LV mass index compared to normotensive controls.

As shown in table 3, the mean LV wall stress calculated by using Grossman equation was significantly higher among hypertensive compared to normotensive controls (188.4 $\pm$ 15.4 Vs 131.6 $\pm$ 4.6 Kdyen/cm^2). Hypertension is associated with 43.2% increase in LV wall stress compared to normotensive controls.

To evaluate the functional efficiency of LV during systole, the functional parameter have been studied such as mean stroke volume, ejection fraction and mean fractional shorting (%).

As shown in table 4, the mean ejection fraction (%) was significantly lower among hypertensive than normotensive control (57.1 $\pm$ 3.3 Vs 70.6 $\pm$ 2.1). the mean stroke volume and the mean fractional shorting on the other hand was obviously lower in hypertensive subjects, however the differences observed between hypertensive and normotensive controls failed to reach the level of statistical significance (71.1 $\pm$ 6.2 Vs 86.5 $\pm$ 8.2 mL) and (30.4 $\pm$ 1.8 Vs 34.9 $\pm$ 1.6).

Hypertension is associated with 17.8% decrease in stroke volume, 19.1% decrease in ejection fraction and 12.9% decrease in fractional shorting compared to the normotensive controls.

Table 1: Difference in mean interventricular wall thickness between hypertensive and normotensive group.

	Normotensive (n=15)	Hypertensive (n=15)	P (t-test)	Difference attributed to hypertension as a percentage of normotensive mean
Interventricular septal thickness in systole(mm)			0.1[NS]	
Range	(10 – 19)	(10 – 20)		
Mean	12.8	14.5		13.0%

SE	0.58	0.79		
Interventricular septal thickness in diastole(mm)			0.01	
Range	(8 – 13)	(7 – 22)		
Mean	9.9	13.1		32.2%
SE	0.44	1.03		

Table 2: Difference in mean LV mass between hypertensive and normotensive group.

	Normotensive (n=15)	Hypertensive (n=15)	P (t-test)	Difference attributed to hypertension as a percentage of normotensive mean
Left ventricular mass (gm)			0.003	
Range	(101,1 – 230,2)	(104,5 – 405,3)		
Mean	165.7	249.4		50.5%
SE	10.03	22.0		
LV mass index (gm/m2)			0.002	
Range	(54.7 – 132.5)	(65.4 – 217.5)		
Mean	90.4	131.3		45.3%
SE	5.33	10.56		

Table 3: Difference in mean LV wall stress (Kdyen/cm2) using Grossman equation between hypertensive and normotensive group.

	Normotensive (n=15)	Hypertensive (n=15)	P (t-test)	Difference attributed to hypertension as a percentage of normotensive mean
Mean LV wall stress in Kdyen/cm2 using Grossman equation			0.003	
Range	(97 – 171.3)	(107.7 – 320)		
Mean	131.6	188.4		43.2%
SE	4.63	15.35		

Table 4: Difference in mean of selected each indices of LV systolic function between hypertensive and normotensive group.

	Normotensive (n=15)	Hypertensive (n=15)	P (t-test)	Difference attributed to hypertension as a percentage of normotensive mean
Stroke volume (mL)			0.15[NS]	
Range	(35.8 – 132.9)	(35.7 – 131)		
Mean	86.5	71.1		-17.8%
SE	8.15	6.21		
Ejection fraction (%)			0.002	
Range	(59.1 – 85)	(39.7 – 81.3)		
Mean	70.6	57.1		-19.1%
SE	2.16	3.33		
Fractional shortening of left ventricle (%)			0.08[NS]	
Range	(26.1 – 47)	(19.3 – 43.5)		
Mean	34.9	30.4		-12.9%
SE	1.55	1.87		

Validity of LV mass index in diagnosing chronic effects of hypertension

Among all the echocardiographic parameters studied, the LV mass and LV mass index showed the highest difference in mean between hypertensive and normotensive groups, where hypertension was associated with 45.3 % increase in LV mass index compared to that in normotensive subjects. From the above mentioned reasons the LV mass index was used as a criteria for diagnosing the chronic effects of hypertension at pre-selected cut off value considering the test as positive if its value is equal to or higher than the cut off value.

As shown in figure 1, the LV mass index criteria was associated with an ROC area under the curve of 0.81 which was significantly higher than the equivocal test of 0.5. The most sensitive cut off value was 62(gm/m^2) which is 100% sensitive and 13.3% specific. At this cut off value and no previous knowledge about the pretest probability of having hypertension (50% chance) a negative test will exclude a possible diagnosis of hypertension with 100% confidence, while a positive test is not useful in establishing the diagnosis of hypertension positive predictive value (PPV) = 53.6%. At the other extreme the most specific cut off value is 133.3(gm/m^2) , at which the specificity is 100% and the sensitivity is 53.3%. At this cut off value and no previous knowledge about the pretest probability of having hypertension (50% chance) a positive test will establish the diagnosis of hypertension with 100% confidence, while a negative test is not useful in excluding the diagnosis of hypertension.

The optimal cut off value, the one with highest accuracy, for the LV mass index in differentiating between hypertensive from normotensive subjects is 118.5(gm/m^2) , which is associated with a sensitivity of 66.7% and specificity of 93.3%. At this cut off value and no previous knowledge about the pretest probability of having hypertension (50% chance) a positive test will establish the diagnosis of hypertension with 90.9% confidence, while a negative test is less reliable in excluding the diagnosis of hypertension negative predictive value (NPV)=73.7%.

Table 5: The validity of 3 selected cut off values of LV mass index (gm/m^2) in the diagnosis of chronic effects of hypertension. The criterion is considered positive if its value is equal to or higher than the cut off value

Cut off value for LV mass index	Sensitivity	Specificity	Accuracy	PPV	NPV
Most sensitive (62.0)	100	13.3	56.7	53.6	100
Optimal value (118.5)	66.7	93.3	80.0	90.9	73.7
Most specific (133.3)	53.3	100	76.7	100	68.2

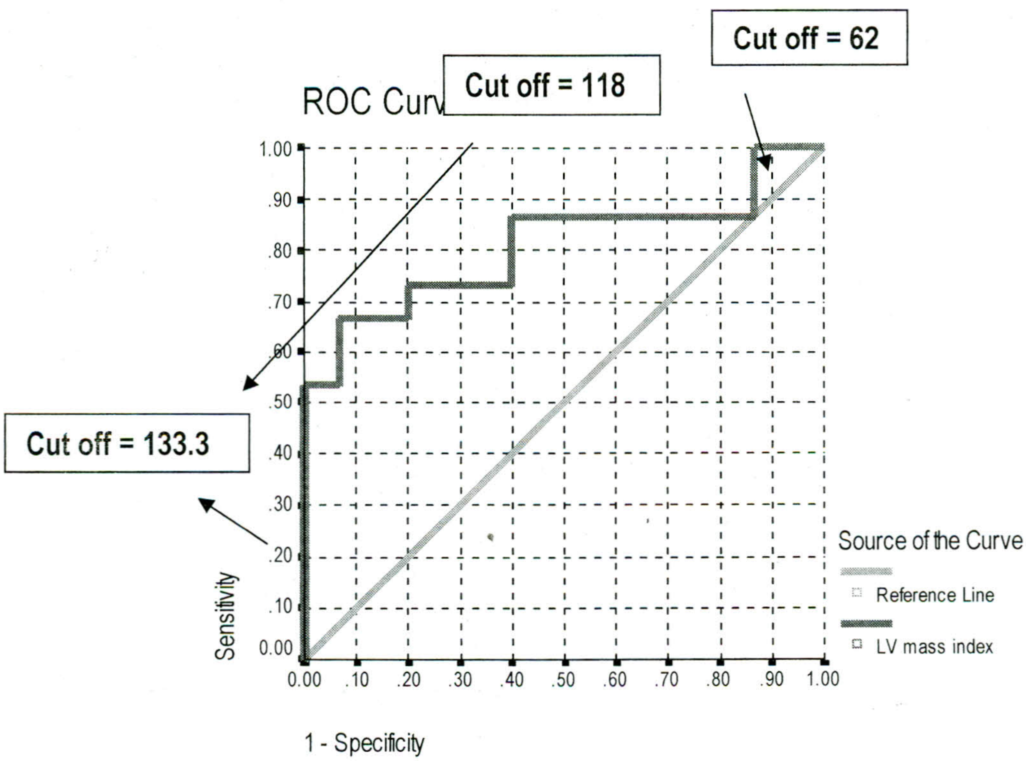

Figure 1: ROC curve showing the trade-of between sensitivity (true positive) and false positive (1-specificity) of all available cut off values for LV mass index in the diagnosis of chronic effects of hypertension. The criterion is considered as positive if its value is equal to or higher than the cut off value.

Area under the ROC curve=0.81 and its SE = 0.08. P = 0.004

Discussion:

The present work showed that LV mass index was associated with the highest difference between cases and controls among the 8 echocardiography parameters assessed. Therefore, it is expected to provide the best performance in distinguishing between cases with hypertension and normotensive controls. One should also remember that hypertension is a chronic disease that may be present for years and pass clinically unnoticed. The importance of current work stems from the possibility of raising the clinical suspicion about the presence of hypertension from its chronic effects on LV mass assessed during echocardiography.

The use of LV mass index as a criterion to anticipate hypertension is based on a simple concept: An increase of LV mass index beyond a threshold value makes the diagnosis of hypertension very likely. Presenting the validity of LV mass index in diagnosing chronic effects of hypertension in terms of ROC curve have many advantages:

1. The area under the curve gives an idea about the usefulness of the test and helps in comparing it to other test. The closer the area to one (idea test) the more valid it is. In present study the test proved very useful, since the area was 0.86 and it is was significantly different from the 0.5 area (represent an equivocal test, in which the gain in sensitivity equals the loss in specificity from each unit decrease in cut off values). The larger the area under the curve (closer to one) the more valid the test, since there is a great in sensitivity for minimal losses in specificity.
2. One can select a typical cutoff value which results in a highly valid test (highly specific with reasonably high sensitivity) from the ROC curve, which is the point at which the curve change its direction from step upward to a wore plateau position. This point concide with the highest accuracy. In the present study the optima cutoff value is 118.5 at which the sensitivity is 66.7% and specificity 93.3%.

In this study we depend on a method which used by[14,15]. The method provided a new approach of validating the use of LV mass index in diagnosing the chronic effects of hypertension on the heart.

Conclusions:

Among the 8 echocardiogrphic parameters assessed the LV mass index provided the best test for diagnosing chronic effects of hypertension. The optimal cut off value of LV mass index is 118.5(gm/m^2) at which the sensitivity is 66.7% and specificity 93.3%. In a clinical situation with equal odds of having asymptomatic hypertension, observing an LV mass index of 118.5 (gm/m^2) or higher will establish the diagnosis of hypertension with 90.9% confidence.

References:

1. *Calhoun, D.A.; Bakir, S.E. and Oparil, S.: "Etiology and pathogenesis of essential hypertension". In: grawfors, M.H. and Dimarco, J.P., eds. Cardiology, London, Mosbey, St. Louis, 2001: Section 1.*
2. *Julian, D.G.; Cowan, J.C. and Mclenachan, J.M.: Cardiology, 7th edition. London. New York, W.B. saunders Company, 1998: 69-74.*
3. *Rubin, E. and Farber, J.L.: pathology, 3th edition, New York, lippincott-Ravem, 1998: 509-530.*
4. *Mensah, G.A. and Francis, C.K.: "Complications of hypertension.": In: Edited Crawford, M.H. and Diwarco, J.P., eds. Cardiology, St. Louis, Mosby, 2001: Section 4.*
5. *Kannel, W.B.: contribution of the Farmingham study to preventive cardiology. J. Am. Coll. Cardiol, 1990; 15: 206.*
6. *Haider, A.W.; Chen, L.; Larson, M.G.: Antecedent hypertension confers increased risk for adverse out comes after initial myocardial infarction. Hypertension, 1997.*
7. *Liao, Y.; Cooper, R.S.; McGee, D.L. et al.: The relative effects of left ventricular hypertrophy. JAMA, 1995; 273: 1592-7.*
8. *Levy, D.; Garrison, R.J.; Savage, D.D. et al: Prognostic implication of echocardiography determined left ventricular mass in Framingham heart study. N. Engl. J. Med., 1990; 332: 1561-6.*
9. *Koren, M.J.; Devereux, R.B.; Casale, P.N. et al.: Relation of left ventricular mass and geometry to morbidity and mortality in uncomplicated essential hypertension. Annals Intern. Med., 1991; 114: 345-52.*
10. *Deveroux R.B., Alonson D.R., and lutaus E.M : Echocardiography assessment of left ventricular mass,comparison to necropsy finding . Am J cardiol 1986 ; 57: 450-458 .*
11. *Levy D., Savage D.D., and Carrison R.J.: Echocardiographic criteria for left ventricular hypertrophy . Am J cardiol 1987 ; 59 : 956-960 .*
12. *Harris D.T., Gilding H.P., and Smart W.A.: Experimentel physiology , 5th edition , London , J. Churchill LTD , 1951 : 127-130 .*
13. *Reichek, N.; Wilson, J.; Sutton, J. et al.: Noninvasive determination of LV end systolic stress. Circulation, 1982; 65: 99-108.*
14. *Verdecchia, P.; Schillact, G.; Borgioni, C. et al.: Prognostic value of left ventricular mass and geometry in systemic hypertension with ventricular hypertrophy. Am. J. Cardial., 1996; 78: 197-202.*
15. *Gerds, E.; Zabalgoitia, M.; Biornstad, H. et al: Gender difference in systolic left ventricular function in hypertensive patients with electrocardiographic left ventricular hypertrophy. Am. J. Cardiol., 2001; 87: 980-83.*