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IMPACT OF ASYMPTOMATIC HYPERTENSION ON LEFT VENTRICULAR FUNCTIONS

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Abstract : (M-Mode Echocardiography was used to study the L.V. Systolic functions and the determinants of L.V. functions in subjects with asymptomatic Hypertension in comparison with subjects with normotensives. The functions were assessed among (60) sixty healthy subject and sixty (60) hypertensive subjects. The L.V. Function Parameters assessed by Echocardiography at lateral and septal sides of Left ventricle at the level of mitral annulus. Techholz's formula was used to measure the stroke volume, ejection fraction, cardiac output and cardiac index etc... The resting stroke volume, cardiac output and cardiac index were normal but significantly high among hypertensive subjects compared to normotensive subjects ($P<0.05$). The fractional fiber shortening (F.F.S.) and other parameters of L.V. contractile state were significantly reduced among hypertensives compared to normotensives ($P<0.05$). The significant Impairment of F.F.S. is due to alteration in dimension of L.V. wall thickness, L.V. cavity, L.V. geometry and fibrous changes in L.V. myocardium. This carries prognostic implication and requires further documentations, investigations and researches. As the R.A.A.S. play role in development of structural changes in L.V. wall drugs A.C.E. inhibiters i.e. Captopril and A.II.R. antagonist i.e. Losartan play significant role in improvement of L.V. functional changes. Even in the presence of normal L.V. systolic function, the L.V. hypertrophy is associated with altered L.V. geometry. Normal or near normal F.F.S. is considered a hallmark of normal L.V. function when L.V. geometry is normal, but not when L.V. hypertrophy type of geometry. Normal limit of F.F.S. should be reset to newer value. The L.V. contractile state was negatively correlated to L.V. after load parameters. So the main objective of management of hypertensive subjects should be, to reduce the after load to improve the L.V. contractile state.)

Key words : left ventricular functions, determinant of L.V., assessment, M-Mode echocardiography, function after load, asymptomatic hypertension, left ventricular hypertrophy, L.V., left ventricle

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INTRODUCTION

L.V. systolic functions are routinely assessed by Echocardiography method in clinical setup. Among asymptomatic subject of hypertension, the resting L.V. systolic function i.e. stroke volume, cardiac output are normal. The determinant of L.V. functions i.e. preload, after load, contractile state of L.V. can also be assessed by Echocardiography. The important and reliable parameters of determinant of L.V. functions can be measured safely, non-invasively, quickly, without any radiological or any other hazards with the help of Echocardiography. These parameters can be used for the early detection of L.V. systolic dysfunction, progress of L.V. Dysfunction, effect of therapeutic intervention i.e. pharmacological and/or non-pharmacological method on L.V. functions. The present study described the assessment of L.V. systolic functions and determinants of L.V. functions by M-Mode Echocardiography among hypertensive and normotensive group of subject and its possible implications.

METHODS

Randomized sixty asymptomatic hypertensive and sixty healthy normotensive subjects were assessed clinically by history and physical examination for cardio-vascular health states point of view. All the subjects were undergone M-Mode Echocardiography examination for the assessment of L.V. systolic functions and the parameters of determinants of L.V. functions. The following parameters were measured–

(A) L.V. Systolic functions.

(A1) Stroke volume. (S.V.) stroke volume, was measured by considering the L.V. as a prolate Ellipse.

In this geometrical concept, the S.V. can be calculated by following formula

$S.V. = (LVID_d)^3 - (LVID_s)^3$ where $LVID_d$ = left ventricular internal diameter at diastole and

$LVID_s$ = left ventricular internal diameter at systole.

(A2) Cardiac output (CO.) = Stroke volume x heart rate

(A3) Cardiac index (C.I.) = Cardiac output/Body surface area

(A4) Stroke volume index (S.V.I.) = stroke volume/Body surface area

Determinants of L.V. function–

(B) Parameters of contractile state of L.V.

(B1) Ejection fraction (E.F)

$$E.F.\ cube = \frac{(LVID_d)^3 - (LVID_s)^3}{(LVID_d)^3}$$

This E.F. can be regressed to corrected E.F. by Teichholz's Formula

$$E.F.\ Teichholz = \frac{7.0}{2.4 + LVID_d} \times E.F.\ Cube$$

(B2) Fractional Fibre Shortening (F.F.S.)

$$F.F.S. = \frac{EDD - ESD}{EDD}$$

Where EDD = End Diastolic Diameter
ESD = End Systolic Diameter

(B3) Percentile change in FFS :

$$F.F.S.\% = \frac{EDD - ESD}{EDD} \times 100$$

Where EDD = End Diastolic Diameter
ESD = End Systolic Diameter

(B4) Mean Velocity of circumferential fiber shortening (Mean V-CFS)

$$Mean V - CFS = \frac{EDD - ESD}{EDD \times ET}$$

Where EDD = End Diastolic Diameter
ESD = End Systolic Diameter
ET = Ejection time

ET = Ejection time can be measured by the time from QRS peak to maximum anterior displacement of posterior wall of LV in systole or it can also be determined by measuring the time from beginning from posterior wall movement anterior to it's maximum anterior position in the absence of ECG. Normal value is 0.9 to 1.8 circumferences per second

(C) Parameter of Preload :

(C1) Index of preload = EDV/BSA where
EDV = End Diastolic Volume
BSA = Body Surface Area

(D) Assessment of After Load :

(D1) Peripheral arterial resistance =

$$\frac{\text{Mean BP X 1.333}}{\text{Cardiac Output}}$$ in dyne cm^{-5} Second

Peripheral arterial resistance does not reflex the after load status at L.V. myocardial level. The after load seen at L.V. myocardial level is actually the systolic wall force or stress. This wall force or stress can be assessed by use of law of Laplace i.e. T = P + r/2h where T = wall tension or stress; P = pressure, r = radius of L.V., h = thickness of L.V. wall.

Echocardiography provides adequate data to measure the L.V. stress by using the concept developed by Grossman and extended by Quinone and Reicheck. Following mathematical formula measure two types of L.V. stress i.e. ESS = End Systolic Stress and EISS = End Isovolumetric Systolic Stress to assess the L.V. after load.

(D2) ESS (End Systolic Stress)

$$ESS = \frac{0.33 \text{ X ESD X SBP}}{PWT\left(1 + \frac{PWT}{EST}\right)} \text{ (Diastolic Blood pressure)}$$

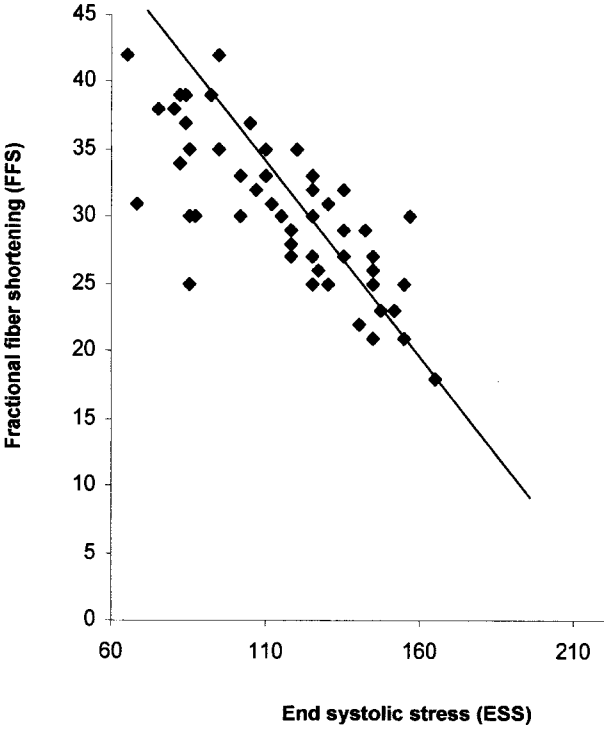
Where ESD = End Systolic Diameter of LV
EDD = End Diastolic Diameter of LV

PWT = Posterior wall thickness of LV
SBP = Systolic Blood Pressure
DBP = Diastolic Blood Pressure

(D3) EISS (End Isovolumetric Systolic Stress)

$$EISS = \frac{0.33 \text{ X EDD X DBP}}{PWT\left(1 + \frac{PWT}{EDD}\right)} \text{ (Diastolic Blood pressure)}$$

Statistical test : Statistical tests, here used to compare the parameters among hypertensive and normotensive groups were the measurement of standard error of



Graph No. 1: Graph showing negative co-relation between FFS (Contractive state of left ventricle and ESS (index of LV wall stress/ after load).

means. The standard normal table was referred to measure the P-value. The tests were considered Statistically significant if the P-values were <0.05. (The null-hypothesis was applied). To know the interrelationship between L.V. functions and parameter of determinants of L.V. function, graphic method was use for the correlation analysis.

Observations

Total sixty randomly selected asymptomatic hypertensive (Mean Age 50.12 – SD 8.2, 32 males and 18 females) and sixty healthy normotensive (Mean Age 43.7 – SD 7.8, 48 males and 12 females). Subjects were assessed clinically and by M-Mode-echocardiography. The parameters of overall LV functions and parameters of determinants of LV functions were measured and are summarized in Table I.

TABLE I: The table showing parameters of left ventricular functions among normotensive andd hypertensive subjects determined by M-Mode Echocardiography.

NO O/C	*L.V. function parameters parameters*	*Normotensive group*		*Hypertensive group*		*P. value*
		Mean	*S.D.*	*Mean*	*S.D.*	
1	S.V. index	44.46	13.098	56.86	19.480	<0.05
2	Cardiac index	3.47	0.966	4.38	1.352	<0.05
3	Ejection fraction	0.648	0.139	0.60	0.072	<0.05
4	FFS%	33.20	6.20	30.92	4.90	<0.05
5	MeanV CES	1.48	0.27	1.22	0.184	<0.05
6	P.A.R.	1381.00	474.00	1617.00	357.000	<0.05
7	ESS	90.60	15.43	119.46	25.309	<0.05
8	EISS	94.73	11.49	113.52	30.199	<0.05
9	Preload index	64.40	14.88	86.44	24.597	<0.05
10	Systolic BP	114.00	6.80	183.50	28.200	<0.05
11	Diastolic BP	74.00	5.80	107.00	10.300	<0.05
12	Heart rate	78.25	4.68	77.76	6.480	N.S.
		n1 = 60		n2 = 60		

Correlation analysis were carried out between L.V. Systolic function parameter and parameters of determinants of L.V. functions. The most interesting observation was the negative correlation between L.V. systolic function (FFS%) and L.V. after load (ESS). This observation is demonstrated in graphic form in Graph No. 1.

Graph No. 1 Showing the negative correlation between FFS (contractile state of L.V. and ESS) index of L.V. wall stress/after load.

TABLE II

	Name of mechanism		*Limitation of mechanism*
(A)	Increase volume	i.e.-starling mechanism -Length tension curve of sarcomere	(1) Structure of sarcomere (2) Fibril slippage (3) Laplace's law
(B)	L.V. hypertrophy	Increased Myocardial mass	(1) Force/unit mass decrease (2) Myosin ATPase
(C)	Increase Sympathetic, RAAS activity	Nor epinephrine Release Renin Release	(1) N.E Depletion (2) Reduction in tyrosin hydroxylase enzyme activity

DISCUSSION

In the presence of unnaturally increased arterial Blood pressure, due to any cause, the heart must maintain a normal cardiac output to preserve the consistence of the milieu interior of Claude Bernard-the composition of extra cellular fluid in which the cellular functions depend. The heart can accomplish this augmented workload only by expenditure of energy accompanied by physiological stretching of cardiac muscle fibres, which ultimately undergo hypertrophy i.e. left ventricular hypertrophy. Here the relationship is quantitative. When L.V. is exposed to chronic elevation of after load i.e. hypertension, L.V. have following compensatory mechanisms to work under such stress (Table II).

The present study documented the fact that the resting systolic L.V. function parameters i.e. Stroke volume, cardiac output... are normal among asymptomatic hypertensive subjects. Though further studies are required to document the behavior of L.V. during and after exercise. These parameters were significantly high among hypertensives compared to normotensive subjects ($P<0.05$). The Parameter of preload i.e. E.D.V./B.S.A. is significantly high among hypertensives compared to normotensive subjects ($P<0.05$). These data can be explained by compensatory mechanism i.e. increased sympathetic activity, Renin-Angiotensin-Aldosterone System (RAAS) i.e. Table No. II. The parameters of after load i.e. E.S.S. and E.I.S.S. were significantly high among hypertensives compared to normotensive subjects ($P<0.05$). The parameters of L.V. Contractile state i.e. F.F.S., Mean V.C.F.S. were significantly low among hypertensives compared to normotensive subjects ($P<0.05$).

By correlation analysis (graphic method), it was found that the L.V. wall stress (E.S.S.) is the Predictor of L.V. Myocardial contractile state. The graph no. 1 shows the significant negative correlation between L.V. wall stress (E.S.S.) and L.V. fractional fibre shortening (F.F.S.). The relation here is negative one and highly significant. This means that L.V. myocardial contractile performance is dependent on L.V. wall stress. The performance can be improved by decreasing the L.V. wall stress.

After load (E.S.S., E.I.S.S.) is the force distributed in the ventricular wall during

ventricular ejection. This force is a complex in the intact heart and dependent on viscous and inertial properties of the blood, ventricular volume, L.V. wall thickness and peripheral arterial resistance. The wall force/after load during ejection of L.V. influences the quantity of blood ejected by ventricle, i.e. abrupt increase or decrease in impedance of L.V. ejection inversely alter the stroke volume and do so when end diastolic volume is independently controlled. It should be emphasized here further, that after load is never constant during ventricular ejection, but continuously decline as the L.V. volume and midwall radius decrease as predicted by Laplace relation (i.e. T = PxR/2h where T = wall stress/tension, p = pressure, R = radius of L.V. and h = thickness of L.V. wall.) This type of cardiac contraction with continuously varying load is called auxotonic contractions (neither isotonic nor isometric). Increasing the after load result in reduction of contractility, velocity of wall shortening and fibre shortening (FFS and MeanV CFS). Increasing after load (ESS, EISS) causes immediate negative changes myocardial wall shortening and contractile state. This has immediate implication that is to do research for pharmacological agents/ molecules which has direct impact on reduction in after load at L.V. myocardial level to improve the contractile state of myocardium among the hypertensive subjects. In this context, echocardiography is very useful tool to measure the parameter of after load i.e. ESS, EISS quantitatively and non-invasively, to evaluate the effect of pharmacological and non pharmacological methods for their effect on after load.

The significantly increased wall stress is due to altered structure and geometry of L.V. i.e. left ventricular hypertrophy which can be of concentric or eccentric type. Certain pharmacological interventions i.e. ACE Inhibitors i.e. Lisinopril, Angiotensin II Receptor Antagonists i.e. Losartan not only reduce the blood pressure but also reduce the after load and correct/regress the L.V. hypertrophy. They modify altered L.V. geometry toward the normal side. This correction of L.V. geometry and L.V. wall stress can lead to normalization of the contractile state of left ventricle. The elevated blood pressure is related and product of cardiac output and peripheral arterial resistance, while after load and L.V. wall stress are product of L.V. diameter, L.V. wall thickness and aortic pressure. An increase arterial blood pressure augments after load and L.V. stress by negative feedback mechanism. This depresses the myocardial fibre shortening. This further decrease the myocardial performance and the viscous cycle is once on lead to progressive impairment of myocardial performance.

In this context, it is worth to consider the Framingham-study which have stated that the most important means of preventing the cardio-vascular complication is to identify and treat hypertension before complication develop. In this point of view, the echocardiography is very useful tool in demonstrating abnormalities in L.V. performance and supplying additional clue to a newer concept of hypertension as a disease process (in degree) rather than a manifestation of underlying disease. In this context, epidemiological approach by

detecting the hypertension in early phase is the final reply for the prevention of hypertensive heart disease process. With the same objective, the study was carried out among the asymptomatic hypertensive subjects to assess the L.V. functions by using the echocardiography.

Conclusion and implications

From the study, it can be concluded that the overall L.V. systolic functions were normal among the asymptomatic hypertensive subjects. Though, the further studies are required to document the behavior of L.V. under pharmacological and physiological stresses i.e. Physical exercise or emotional excitement. Normal L.V. systolic functions, even upon the diminished the contractile state of L.V. can be explained on the basis of compensatory mechanisms which may compromise or exhausted on exposure to stresses. The negative correlation between contractile state of L.V. (FFS) and after load (ESS) lead to recommend the requirement of early reduction of after load to improve the contractile state of L.V. The decreased contractile state is due to altered structure and geometry of L.V. Certain pharmacological intervention i.e. ACE Inhibiters i.e. Lisinopril, Angiotensin II Receptor Antagonist i.e. Losartan are found to modify the L.V. structure and geometry favourablely by reducing the L.V. myocardial stress, though more studies and researches are required. Here it is further recommended to carry out more researches to find out the newer pharmacological agents, which can normalize the L.V. structure - geometry and reduce the stress at L.V. myocardial level to improve the contractile state of L.V.

Ejection fraction and fractional fibre shortening are hallmark of L.V. pump functioning. Their normal limits and normal values for normal ventricles and hypertrophy ventricles are to be reestablished, as their same value/limit does not appear to be compatible in both the circumstances.

Large number of pharmacological and non-pharmacological methods have recommended for the management of hypertension. Their role at the level of L.V. wall stress and L.V. contractile state are to be established precisely by large-scale multicentric study. Another conclusion drawn from the study is that all the subjects were inadequately treated for hypertension because of asymptomatic nature of the disease. Tremendous public awareness programs are to be set up to educate the people about the early detection and benefit of control of blood pressure by various means for the benefit and improvement of cardiac physiology and L.V. function even the hypertension is in asymptomatic stage.

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