An Echocardiographic Evaluation Of Left Ventricular Systolic Functions In Hypertensive Patients*

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Summary:

A total of 30, consecutive, hypertensive patients, equally divided between the two sexes, were evaluated by M mode & 2-D echocardiography. They were divided into four groups; Group A — Left ventricular (L.V.) mass < 100 g/m². Group B — LV mass = 101 — 125 g/m². Group C — LV mass = 126 — 150 g/m². Group D — LV mass > 150 g/m².

All patients (n=7) in group A had normal LV systolic function as determined by E-point-to-septal separation (E.P.S.S.), Ejection Fraction (E.F.) & Fractional Shortening (F.S.) excepting one patient with a minimally increased E.P.S.S. Of 11 patients in group B, eight (72.5%) showed increased E.P.S.S. whereas only one of these eight patients had reduction in E.F. & F.S. as well. The other three patients had normal E.P.S.S., E.F. & F.S. Group C consisted of six patients. All (100%) of these had increased E.P.S.S. but normal E.F. & F.S. Group D also had six patients. Of these four (66%) had prolonged E.P.S.S. whereas three of these four patients had reduced E.F. or F.S. as well. The other two patients had normal E.P.S.S. & F.S.

In conclusion, this study suggests a direct correlation of increasing LV mass with progressive LV systolic dysfunction in hypertensive patients. Also, increased E.P.S.S. appears as the first abnormality of LV systolic function before reduction in E.F. or F.S.

Introduction:

Hypertensive heart disease is an important and common cause of morbidity and mortality[1]. As the systemic arterial pressure goes up, the cardiac workload is increased[2]. To overcome this after load, certain changes take place in the heart, predominantly in the left ventricle. Initially, it may involve augmented venous return, i.e., pre-load[3] thus increasing ventricular ejection through the Frank-Starling mechanism. Enhanced ventricular contractility may also be achieved through a state of increased adrenergic input to the myocardium[4]. These findings may not only be the adaptive responses of the heart but may actually be part of an overall pathophysiological process in hypertension[5]. In any event, these changes cause increased myocardial tension and subsequent left ventricular hypertrophy[6]. As a result of left ventricular hypertrophy (L.V.H.), initially the systolic functions are well maintained or may even be high normal[7,8] but as the disease process continues, ventricular contractility becomes impaired in spite of the persistent cardiac capability to increase its mass through the process of hypertrophy. Eventually, unless there is a therapeutic intervention, the ventricle starts dilating and left ventricular failure results[9].

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Measurements of left ventricular performance have proved to be an important indicator of prognosis in patients with many forms of heart disease[10]. Consequently, there has been a great deal of interest in the non-invasive evaluation of left ventricular function with echocardiography which is a reliable investigation to know the functional status of the myocardium, particularly the left ventricle[11]. Several groups have found correlations between echocardiographically and angiographically determined ejection fraction[12-16] and other measures of contractile function[17].

TABLE 1

	Group A	7 Patients		LV Mass<100 g/m²
No.	LV Mass g/m²	E.P.S.S. mm	E.F. %	F.S. %
1.	80.9	5	70	42
2.	90.6	2	60	26
3.	76.8	3	64	28
4.	65.4	5	67	31
5.	71.0	5	59	26
6.	90.3	6	63	28
7.	76.4	5	76	38

Ejection fraction (E.F.) and fractional shortening (F.S.) of the myocardium are well recognized parameters of left ventricular systolic function. 'E' point to septal separation (E.P.S.S.) is also reported to be a good index of left ventricular systolic function in studies done by Lew et al.[18] in ischemic heart disease and by Massie and coworkers[19] in a mixed group of cardiac patients.

We did an echocardiographic study in hypertensive patients to find out which of these echocardiographic parameters would warn us about deterioration in left ventricular systolic function at the earliest.

Patients and Methods:

The study consisted of 32 consecutive, hypertensive, patients who attended the medical outpatient department of Sheikh Zayed Hospital, Lahore, during a period of one month. Patients with history of hypertension (defined according to the Joint National Committee Criteria)[2] were included regardless of their age, sex, weight, height and whether blood pressure was controlled or not at the time of presentation. Patients with evidence of valvular heart disease or ischemic heart disease were excluded.

Electrocardiogram (E.C.G.) and X-ray chest were done by trained technicians. Echocardiographic examination of each patient was done by an experienced cardiologist who knew nothing about the severity or duration of hypertension or the patient's medication. Echocardiography was done using a Sonolayer SSH-40A Toshiba machine with a 3.5 MH transducer in partial left lateral position and all standard views were taken. Left ventricular M-mode echocardiograms were taken just below the level of the tips of the mitral valve leaflets showing clear continuous echoes from both the septum and the posterior wall. Thickness of septum and posterior wall were measured at end-diastole (R wave on ECG). E.P.S.S. was measured as the minimal distance between the E-point of anterior mitral valve leaflet to a line drawn tangent to the most posterior excursion of the interventricular septum within the same cardiac cycle[18,19]. End-diastolic as well as end-systolic dimensions were measured and left ventricular function including E.F. and F.S. calculated by the in-built computer by POMBO method.

TABLE 2

	Group B	11 Patients		LV Mass 101-125 g/m²
No.	LV Mass g/m²	E.P.S.S. mm	E.F. %	F.S. %
1.	115.0	7	71	34
2.	103.8	0	65	30
3.	109.2	6	65	30
4.	115.0	7	73	36
5.	119.6	10	58	25
6.	123.4	6	70	33
7.	110.0	6	70	30
8.	120.0	5	75	37
9.	112.2	7	71	33
10.	117.7	4	73	36
11.	103.1	6	52	22

Normal values were taken as E.F. > 55%, F.S. > 25% and E.P.S.S. < 6mm. Left ventricular mass was calculated by the formula[21];

L.V. mass = 1.04 [(LVID+PWT+IVS)^3] - (LIVD)^3 - 13.6G.
LIVD: left ventricular internal diameter in diastole.
PWT: Posterior wall thickness.
IVS: Interventricular septal thickness.

Electrocardiograms were read by another physician who did not know about the echocardiographic findings of the patients. He used the revised criteria for detecting L.V.H. on ECG introduced by Casale P.N.[22].

TABLE 3

	Group C 6 Patients			LV Mass 126-150 g/m^2
No.	LV Mass g/m^2	E.P.S.S. mm	E.F. %	F.S. %
1.	134.4	6	59	25
2.	128.3	6	76	38
3.	134.5	12	63	28
4.	136.5	6	83	44
5.	144.0	6	60	27
6.	147.4	7	84	46

Results:

A total of 32 consecutive hypertensive patients were evaluated. Two of these were excluded because of inadequate echocardiograms. Of the rest, 15 were males and 15 females. Ages of the patients ranged from 14 years to 75 years, average being 46.6 years. Duration of known hypertension ranged from recently diagnosed to 20 years. Eight patients had blood pressure controlled with medication at the time of presentation while 22 were uncontrolled. Patients were divided into four groups according to the left ventricular mass/m^2 calculated by echocardiography.

Group A: Left ventricular mass (L.V. mass) < 100 g/m^2.
Group B: L.V. mass = 101-125 g/m^2.
Group C: L.V. mass = 126-150 g/m^2.
Group D: L.V. mass > 150 g/m^2.

Echocardiographic findings of these various groups are shown in Tables 1,2,3,4.

TABLE 4

	Group D 6 Patients			LV Mass>150 g/m^2
No.	LV Mass g/m^2	E.P.S.S. mm	E.F. %	F.S. %
1.	166.3	15	43	17
2.	243.7	11	59	26
3.	180.6	6	56	24
4.	226.4	4	74	36
5.	172.8	4	68	31
6.	203.6	9	53	24

Of 30 hypertensive patients, 23 had left ventricular mass greater than 100 g/m^2. 18(78%) of these 23 patients showed increased E.P.S.S. on echocardiography whereas only four (17%) of these had reduced E.F. or F.S. as well.

When left ventricular functions of various groups were analysed, all patients (n=7) of group A, except one, had normal E.P.S.S., E.F. & F.S. The one patient with abnormal function was also having only borderline prolonged E.P.S.S., i.e., 6mm.

There were 11 patients in group B. Eight (72.5%) of these showed increased E.P.S.S. whereas only one of these eight (9%) had reduced E.F. & F.S. as well. The other three patients had normal E.F., F.S. & E.P.S.S.

Group C consisted of six patients. All (100%) of these had prolonged E.P.S.S., but normal E.F. & F.S.

Group D also had six patients. Four (66%) of these showed prolonged E.P.S.S. & three of these four patients also had reduced E.F. & F.S. Therefore, the percentage of patients with reduced

E.F. & F.S. was 50% of the whole group. The remaining two patients had normal E.P.S.S., E.F. & F.S.

Represented in the bar diagram (Fig. 1), Group A had an average mass of 79 g/m², Group B 113 g/m², Group C averaged at 137 g/m² while Group D had an average mass of 199 g/m². In Fig. 2, the average E.P.S.S. of each group is shown. It increases progressively, being 4.4mm, 5.8mm, 7.2mm & 8.1mm in Groups A,B,C & D respectively, with increasing LV mass. Taken together (Fig. 3), in Group A, 14% of patients has an abnormal E.P.S.S. with none having an abnormal E.F. or F.S. In Group B, 72% of patients had increase in E.P.S.S. & only 9% had reduction of E.F. & F.S. In Group C, all patients had increased E.P.S.S. & none had reduced E.F. or F.S. while in Group D, 66% had increased E.P.S.S. & 50% had reduced E.F. & F.S.

Echocardiography has become a widely used tool in the assessment of LV function. It is non-invasive, relatively cheap and available in many cities of Pakistan. Its accessibility to a large sector of the population is bound to increase like the spread of general ultrasound machines. We, therefore, carried out this study to evaluate rather simple & easily obtainable echocardiographic criteria of left ventricular systolic function to determine which of these criteria would indicate left ventricular systolic dysfunction earlier in hypertensive patients.

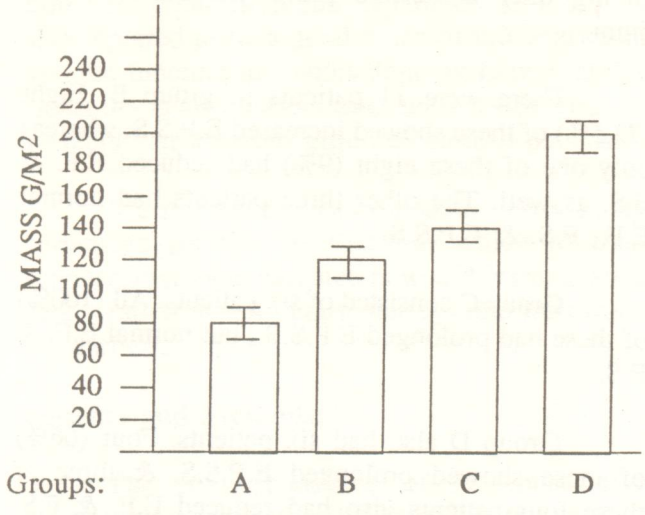

Fig. 1

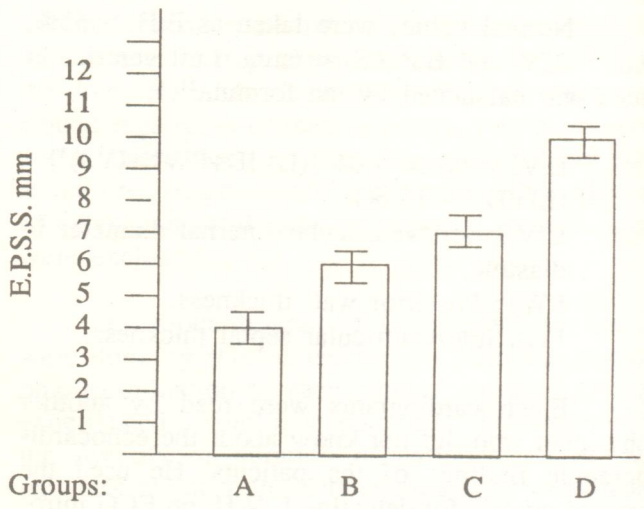

Fig. 2

Our results show that only one patient with LV mass < 100 g/m² had increased E.P.S.S. & that too only minimally so. Of those with LV mass between 101 & 125 g/m², 72.5% had increased E.P.S.S. while only one subject (9%) had mildly reduced E.F. & F.S. All subjects with LV mass 126-150 g/m² had increased E.P.S.S. but normal E.F. & F.S. So far, these results clearly indicate that with progressive increase in LV mass, there is an increase in E.P.S.S. denoting early systolic dysfunction. However, in the group of subjects with LV mass > 150 g/m², this relationship was not so clear-cut. Two of this group did not have increased E.P.S.S. despite severe left ventricular hypertrophy. Both, however, had normal E.F. & F.S. also. The other four subjects in this group had increased E.P.S.S. but only three of these had reduced E.F. & F.S. as well. Thus the contention that increase in E.P.S.S. occurs earlier while reduction in E.F. & F.S. occur late was maintained throughout the whole range of LV mass.

A study by Massie et al.[19] compared E.P.S.S. & other echocardiographic indices of ventricular function with biplane angiographic ejection fraction in 125 patients with a variety of cardiac diseases. It found that compared to other echocardiographic indices, E.P.S.S. correlated more closely with angiographic ejection fraction. In another study, Lew et al.[18] compared E.P.S.S., E.F. & F.S. with radionuclide ejection fraction determined using

the first pass method in 60 patients with ischemic heart disease. They found that increased E.P.S.S. had a specificity of 92% & sensitivity of 65% in identifying a reduced radionuclide ejection fraction. Reduced echocardiographic E.F. had a similar specificity (94%) but a much lower sensivity (only 14%) whereas reduced echocardiographic F.S. has both lesser specificity (64%) & lesser sensitivity (41%).

diographic machine in peripheral hospitals & clinics.

We did not take into account the current or previous medication of the patients. However, we feel this would not have affected the results significantly as only systolic function parameters were evaluated & any drug affecting LV systolic function would have affected all the parameters similarly.

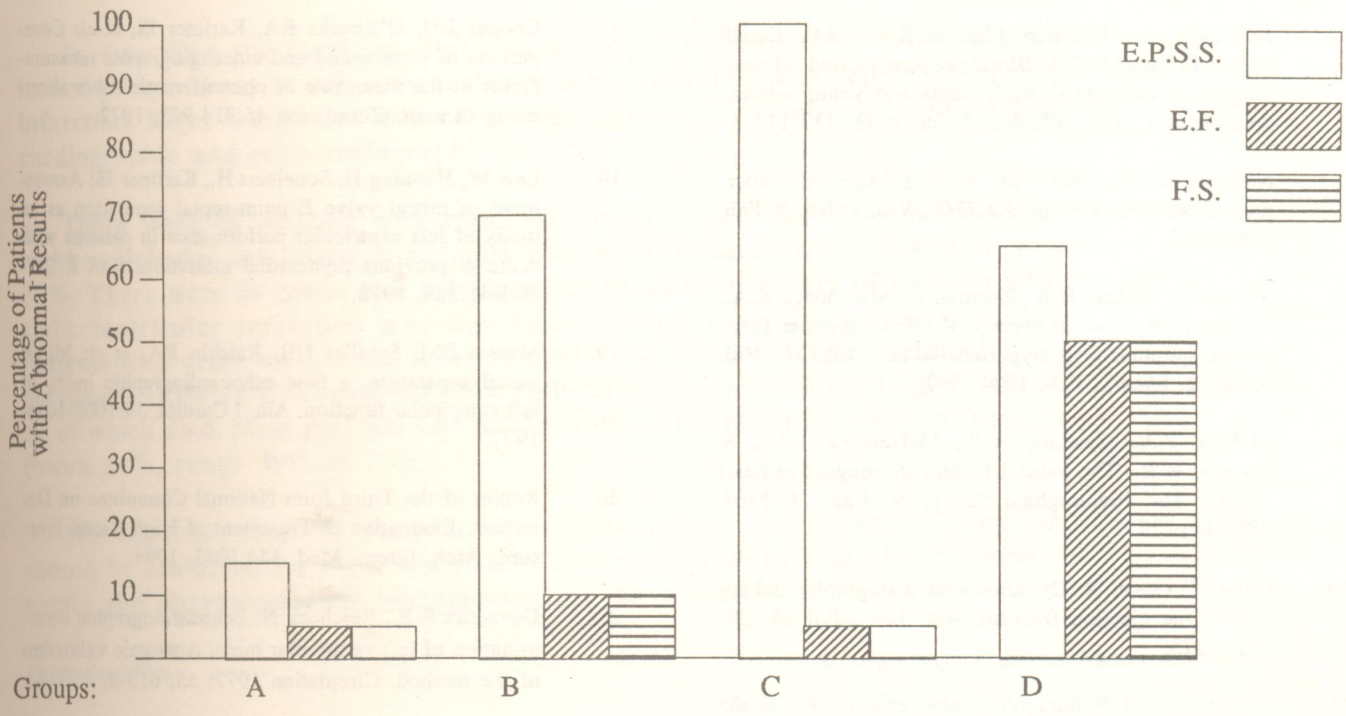

Fig. 3

Previous studies have shown that increased E.P.S.S. is considerably more accurate that other echocardiographic indices in identifying LV systolic dysfunction. Our study shows that in hypertensive patients, increase in E.P.S.S. occurs earlier than reduction in E.F. & F.S. Moreover, the measurement of E.P.S.S. is simple to obtain requiring only visualization of the mitral valve & interventricular septum which can be achieved in virtually all patients even by relatively inexperienced echocardiographers. Simultaneously measurement of the interventricular septum & the posterior left ventricular wall, necessary for most other functional measurements, is not required for this. Therefore, this parameter can be easily obtained using a relatively simple & cheap echocar-

In conclusion, this study suggests that a simply obtainable, M-mode measurement, i.e., E.P.S.S., has a direct correlation with LV mass. Also, increased E.P.S.S. is an earlier marker of LV systolic dysfunction than reduction in E.F. & F.S.

REFERENCES:

1. Castelli, W.P. & Anderson, K: A population at risk. Prevalence of high cholesterol levels in hypertensive patients in the Framingham Study. Am. J. Med 80 (Suppl. 2A): 23, 1986.

2. Katz AM: The cardiomyopathy of overload: A major determinant of prognosis in congestive heart failure. N. Engl J. Med 1990, 322:100-110.

3. Safar, M., Weiss, V.A., London, G.M., Frackowiak,

R.F., & Milliez, P.L: Cardiopulmonary Blood Volume in Borderline Hypertension, Clin. Sci. Molec. Med; 47:153, 1974.

4. Dunn F.G., Chandraratna P.M., De Caruallho J.G.R., Baste L.L., Frohlic E.D. Pathophysiologic assessment of hypertensive heart disease with echocardiography. Am. J. of Card. 1977, 39: 789-795.

5. Juluis S. Pascual A.V., London R. Role of parasympathetic inhibition in hyperkinetic type of borderline hypertension. Circulation; 1971; 44: 413-418.

6. Johnson G.L., Kotchen J.M. McKeen H.E. Cotrill C.M. and Kotchen T.A. Blood pressure related echocardiographic changes in adolescents and young adults. Am. Heart J. Vol. 105, No. 1, Jan 1983: 113-117.

7. Narayan S., Devereux R.B., Lutas E.M., et al. Supernormal left contractility. J.A.C.C., Vol. 3, No. 2, Feb. 1984: 515.

8. Yasuda T., Wilson R.A., Zusman R., Meckusick K.A., Strauss A.W. Natural history of left ventricular function in spontaneously hypertensive rats. J.A.C.C. Vol. 3, No. 2, (Abst)., Feb. 1984: 592.

9. McKee, P.A., Castelli, W.P., McNamara, P.M., & Kannel, W.B.: The natural history of congestive heart failure; The Framingham Study. N. Engl. J. Med. 285:1441, 1971.

10. Cohn PF, Gorlin R: Dynamic ventriculography and the role of the ejection fraction. Am. J. Cardiol 36:529-531, 1975.

11. Feigenbaum H: Echocardiographic examination of the left ventricle. Circulation 51:1-7, 1975.

12. Pombo JF, Troy BL, Russel RO: Left ventricular volumes and ejection fraction by echocardiography, Circulation 43:480-490, 1971.

13. Fortuin NJ, Hood WP, Craige E: Evaluation of left ventricular function by echocardiography, Circulation 46:26-35, 1972.

14. Gilbson DG: Estimation of left ventricular size by echocardiography. Br. Heart J 35:128-134, 1973.

15. Ludbrook P, Karliner JS, Peterson K, et al: Comparison of ultra-sound and cineangiographic measurements of left ventricular performance in patients with and without wall motion abnormalities. Br. Heart J 35:1026-1032, 1973.

16. Belenkle I, Nutter DO, Clark DW, et al: Assessment of left ventricular dimensions and function by echocardiography. Am J Cardiol, 31:755-762, 1973.

17. Cooper RH, O'Rourke RA, Karliner JS, et al: Comparison of ultra-sound and cineangiographic measurements of the mean rate of circumferential fiber shortening in man. Circulation 46:914-923, 1972.

18. Lew W, Henning H, Schelbert H., Karliner JS: Assessment of mitral valve E point-septal separation as an index of left ventricular performance in patients with acute & previous myocardial infarction. Am. J. Cardiol 41:386, 1978.

19. Massie BM, Schiller NB, Ratshin RA, et al: Mitral septal separation, a new echocardiographic index of left ventricular function. Am. J Cardiol, 39:1008-1016, 1977.

20. Report of the Third Joint National Committee on Detection, Evaluation & Treatment of High Blood Pressure, Arch. Intern. Med. 144:1045, 1984.

21. Devereux R.B., Reicheck N: Echocardiographic determination of left ventricular mass, Anatomic validation of the method. Circulation 1977; 55; 613-8.

22. Casale P.N., Devereux R.B., Kligfield P., Eisenberg R.R., Miller D.H., Chaudhry B.S., Phillips M.C. Electrocardiographic detection of left ventricular hypertrophy: development and prospective validation of improved criteria.
J.A.C.C. Vol. 6, No. 3, Sept. 1985: 572-80.