Comparability of M mode echocardiographic long axis and short axis left ventricular function derivatives

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SUMMARY M mode echocardiographic anteroposterior indexes of left ventricular function derived from long and short axis parasternal planes were compared in one hundred cases. In all the disease groups studied the paired values were within acceptable statistical limits of comparability and interchangeability; that is they were within two standard deviations of the mean difference in both directions.

Values from either plane can usually be considered as being representative of the expected values for the individual.

Left ventricular function can be assessed from measurements derived from parasternal long axis left ventricular M mode echocardiographic recordings.¹⁻³ Triulzi *et al* described normal adult cross sectional echocardiographic values.⁴ They found that both the mediolateral and the anteroposterior diameters of the left ventricle measured from the parasternal short axis were consistently larger than the same diameters measured from the apical four chamber and the parasternal long axis views. They attributed the discrepancy between these measurements to slight obliqueness of even an optimally aligned short axis plane. This has left uncertainty about the comparability between short axis and long axis parasternal measurements and whether one set of measurements can be substituted for the other when left ventricular function is estimated. This is especially important when, not uncommonly, good recordings are obtained in only one of the two views. A recent review of recommended standards for M mode echocardiographic measurements did not refer to short axis values.⁵

In a pilot study of left ventricular function from long axis and short axis recordings we were impressed by the similarity of the measurements obtained. We decided to obtain recordings from both axes in all subsequent cases and to examine the

indexes of left ventricular function derived from them, to establish the comparability of left ventricular short axis measurement and those obtained from the standard left ventricular long axis plane.

Patients and methods

We obtained recordings on an Ekoline 5000 (Sunnyvale, Ca) echocardiograph. This gives real time cross sectional sector displays and scrolling or erase bar M mode recordings and a continuously displayed and simultaneously recorded scrolling electrocardiogram. The data were displayed on a 19 cm × 14.5 cm television screen that gave a high resolution image. A hard copy print out was obtained from a stripchart recorder which gave only freeze frame prints (13.4 cm × 9.8 cm). With this size of print and without a stripchart roll for continuous recording it was not possible to record at a paper speed of 100 mm/s, which would have been the ideal paper speed for more elaborate measurements. To obtain tracings of at least five cardiac cycles per print we recorded at speeds of 50 mm and 25 mm per second. We found that the recordings at the slower speeds had the advantage of giving more condensed images with clearer demarcations of the boundaries from which measurements were made. Most of the measurements were made from recordings obtained at a paper speed of 50 mm/s. In a few cases of bradycardia, in which the 50 mm/s recordings gave less than five cardiac cycles, we used

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25 mm/s recordings. There were no important differences in the measurements taken at these two different speeds. The means of measurements obtained during five cardiac cycles were recorded. But the beat to beat measurements and variations were not recorded separately. The freeze frame printouts were internally calibrated, vertically in 1 cm divisions and horizontally in 0.5 s divisions. Video tape recordings of both the M mode and the cross sectional ultrasonic displays were also obtained on JVC (VHS), E-120 Dynarec video cassettes on a built-in video tape recorder for replay and scrutiny. We selected the positions from which the M mode recordings were performed with a cursor appropriately placed in the real time cross sectional image.

A 3.5 MHz sector probe was used in adults and older children and a 5 MHz sector probe in younger and smaller subjects. We used established standards for transducer orientation^{1 6} and for measuring the various dimensions^{1 2 5} and for the derivation of the values from the measurements.^{1 3 7} All measurements were made from leading edge to leading edge. Left ventricular internal end diastolic diameter was measured at the beginning of the QRS complex of the electrocardiogram and left ventricular internal end systolic diameter at the nadir of the left septal systolic motion, unless this could not be determined because of septal motion abnormalities; in this event the peak anterior systolic motion of the left ventricular posterior wall was used. Mitral valve E point septal separation (MVEPSS) was measured in tracings in which both anterior and posterior mitral valve motion were well recorded. MVEPSS₁ was measured from the anterior mitral valve E point maximal upward excursion to the peak downward motion of the left side of the interventricular septum during systole^{1 8} and MVEPSS₂ from the anterior mitral valve E point maximum upward excursion to the left side of the septum at the time of the E point.¹

From 24 November 1983 to 24 September 1984 all patients who had echocardiographic studies performed by PGD in collaboration with ZMS and other technical staff had complete cross sectional and derived M mode echocardiographic recordings taken from the standard left parasternal edge, the cardiac apical, and the subxiphoid positions. In all cases we obtained video tape recordings and freeze frame black and white printouts of both cross sectional real time displays and M mode recordings were taken of the long axis of the left ventricle at the papillary muscle level and at the mitral valve level; of the aortic root short axis (M mode tricuspid valve recordings were also taken at this level); and of left parasternal short axis left ventricular records at the mitral valve, papillary muscle, and left ventricular apical segment at the level of the trabeculae car-

nae.^{4 6} Real time four chamber recordings were obtained at the left ventricular apex, after its location had been established manually, and from the subxiphoid position. All recordings were taken with the patient propped up at about 30° in the semi-left lateral position, except for the subxiphoid recordings which were obtained with the patient in the supine position. In babies and infants, however, all recordings were done in the supine position.

ZMS performed the complete manual analysis of all the echocardiograms. The results were scrutinised by PGD. Those that appeared to be discrepant were rechecked by both PGD and ZMS to find the causes of the discrepancies. No case was discarded because of a difference between the measurements derived from the long axis and short axis planes. For this study we selected the technically best 100 sets of recordings of both the long and short axis parasternal planes from a total of 248 cases. We chose only the best sets because we wished to see whether a good short axis measurement in a given patient was as good as a long axis measurement in the same patient. We compared the following data derived from left ventricular long axis antero-posterior measurements, with corresponding values derived from left ventricular short axis: left ventricular diastolic diameter (LVD-D); left ventricular systolic diameter (LVD-S); left ventricular ejection fraction (LVEF); percentage fractional shortening (%FS); mean velocity of circumferential fibre shortening (VCF); and anterior mitral valve E point septal separation (MVEPSS) (both MVEPSS₁ and MVEPSS₂).^{1 8}

STATISTICAL ANALYSIS

The comparability of the measurements was assessed by the mean of the difference between the long and short axis measurements, plus or minus 2 SD from the mean of this difference. We would expect 95% of pairs of measurements to lie closer together than 2 SD above or below the mean difference; hence this was regarded as a good index of the degree of repeatability and interchangeability of data from the two planes.⁹

Results

We studied 81 male and 19 female patients aged from nine to 83 years (table 1). Except for four cases (one aged 9 years and three aged >60 years) the patients were aged between 14 and 60 years. Table 2 shows the varied diagnostic categories of the cases. Table 3 shows the means and 2 SD of the measurements and their derived indexes. The values of left ventricular diastolic diameter and left ventricular systolic diameter obtained from the short axis

Comparability of *M* mode echocardiographic long axis and short axis left ventricular function derivatives 447

Table 1 Age and sex distribution of the 100 cases

	Age (yr)							
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71+
Male	0	12	33	22	10	2	0	2
Female	1	2	9	2	2	2	1	0
Total	1	14	42	24	12	4	1	2

Table 2 Diagnostic categories of the 100 cases

Diagnostic category	Number
Normal	23
Mitral valve prolapse	17
Septal hypertrophy	7
Cardiomyopathy	8
Ischaemic heart disease	10
Systemic hypertension	4
Aortic disease	3
Rheumatic heart disease	7
Pulmonary disease	2
Congenital heart disease	1
Endocarditis	1
Trauma	1
Miscellaneous	14
Pericarditis	2

plane were not consistently larger than those taken from the parasternal long axis plane, as shown by the small mean difference for all measurements. Corresponding measurements from the two planes showed a high degree of comparability. The upper limits for the difference between indexes derived from the two axes were small compared with the variability of the measurements themselves and they were within the limits of clinical acceptability.

Table 4 shows the 20 cases that had measurements outside the mean $\pm$ 2 SD. Four were normal, four had ischaemic heart disease (one also had associated aortic stenosis and in another there was associated cardiomyopathy); two had cardiomyopathy, three

Table 3 Differences between long axis and short axis left ventricular variables for 100 cases

		LVD-D	LVD-S	LVEF	%FS	Mean VCF	MVEPSS ₁	MVEPSS ₂
Long axis	(Mean (SD))	5.03	3.22	73.6	36.2	1.22	5.3	7.2
		0.72	0.65	8.8	7.0	0.25	4.1	4.2
Short axis	(Mean (SD))	5.00	3.21	73.2	36.0	1.21	5.4	7.2
		0.73	0.65	9.1	6.5	0.26	4.8	4.8
Difference	(Mean (SD))	0.03	0.01	0.4	0.1	0.01	-0.2	0.0
		0.29	0.25	4.9	5.3	0.15	2.4	2.6
Mean - 2 SD		-0.54	-0.49	-9.8	-10.5	-0.31	-5.0	-5.2
Mean + 2 SD		0.60	0.52	9.9	10.8	0.31	4.7	5.2

See methods section for abbreviations.

Table 4 Long axis versus short axis left ventricular function derivatives in discordant cases (outside mean $\pm$ 2 SD)

Case No	Diagnosis	Abnormal variables
5	IHD	LVD-D, LVD-S
10	CM/IHD	LVD-D
11	CM	LVD-D
14	Normal	LVEF, %FS, VCF
18	MVP	LVD-D, MVEPSS ₁
21	Other	LVD-S
24	Septal hypertrophy	LVD-S, LVEF, %FS, VCF
26	Other	LVD-S, MVEPSS ₁
35	RHD	LVD-D
41	Septal hypertrophy	MVEPSS ₁ , MVEPSS ₂
43	Normal	LVD-D
45	MVP	MVEPSS ₁ , MVEPSS ₂
50	Normal	LVD-S, LVEF, %FS, VCF
51	RHD	LVD-D
52	Other	LVD-S
56	AoD/IHD	LVD-D, LVD-S, MVEPSS ₁ , MVEPSS ₂
68	Septal hypertrophy	LVEF, %FS, VCF, MVEPSS ₁ , MVEPSS ₂
77	IHD	MVEPSS ₁ , MVEPSS ₂
82	MVP	LVEF, %FS, VCF
90	Normal	LVD-S

Percentage of discordant cases by variable: LVD-D, 8%; LVD-S, 8%; LVEF, 5%; %FS, 5%; VCF, 5%; MVEPSS₁, 6%; MVEPSS₂, 5%. See methods section for these abbreviations.

IHD, ischaemic heart disease; CM, cardiomyopathy; MVP, mitral valve prolapse; RHD, rheumatic heart disease; AoD, aortic disease.

had mitral valve prolapse, three had abnormal thickening of the interventricular septum; two had rheumatic heart disease, and three had other conditions.

Generally departures from the limits of mean $\pm$ 2 SD were marginal. Moreover, these variations were confined to one index in eight (all related to either left ventricular diastolic or systolic measurements), to two indexes in six cases (related to MVEPSS in five cases and being common to both MVEPSS₁ and MVEPSS₂ in three of them and MVEPSS₁ and left ventricular diameter in two others, and to left ventricular diastolic and systolic diameters in the sixth case). In one other case there were deviations in all four indexes. In the remaining five cases the discordant values were LVEF, %FS, and mean VCF, which are all derived from the same basic measurements. In these cases, however, the left ventricular diameter measurements were not discordant. We could find no explanation for these discordant values. The proportion of such cases was only slightly greater than the 5% expected.

Discussion

Although M mode echocardiographic measurements of left ventricular function are reported to be less accurate than haemodynamically derived estimations,^{10 11} several workers have found a good correlation between angiographic and echocardiographic left ventricular dimensions and function indexes.^{12 13} In patients who are obese or emphysematous, it may be difficult to obtain satisfactory studies from the conventional long axis plane, although it may still be possible to obtain good recordings and measurements from the short axis parasternal view. The current study has convincingly demonstrated that data from short axis recordings are as reliable in the assessment of left ventricular function as those derived from the standard left ventricular long axis parasternal studies and that short axis recordings can be used when adequate long axis parasternal recordings are unobtainable. We did not find that the short axis measurements of left ventricular dimensions were consistently larger than those from the long axis parasternal plane.

Most of the discordant values in the present study showed marginal differences, often of only one or two variables. Thus it may be important not to examine only one variable when left ventricular function is assessed. In one patient with a depressed sternum values from the two planes were discordant, one being normal and the other abnormal. This emphasises the importance of assessing in two planes individuals with altered anatomy. This may also apply to patients with intrinsic cardiac dys-

function such as ischaemic heart disease with ensuing aneurysmal formation, and dyssynergy, asynergy, or other segmental wall motion abnormalities that may cause disparity in the values of left ventricular function obtained from different planes. It is conceivable that asymmetrical left ventricular/septal hypertrophy might also cause similar difficulties. Moreover, although the use of a cursor has improved the accuracy of selecting the levels at which measurements are taken, with most current machines it is not possible to take sample measurements in two planes simultaneously. This introduces the possibility of additional causes of variation in the values obtained from different planes. In addition, single beam echocardiography, assumed ventricular geometry, and varying moment to moment left ventricular contraction patterns introduce approximations that impose additional limitations on the results.

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