Shimane J. Med. Sci. Vol. 3, pp. 57—64, 1979

Cardiac Silhouette Volume and Left Heart Volume in Infants and Children

(cardiac silhouette volume/left ventricular total volume/left ventricular heart volume)

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(Received June 19, 1979)

Quantitative biplane angiographic data were compared to chest X ray data in 173 patients with various heart diseases in infancy and childhood. The patients were separated into four groups on the basis of ventricular overload pattern. Group I consisted of patients without valvular disease and shunt, group II those having left ventricular overload without left to right shunt, group III those with biventricular overload with left to right shunt, group IV those with right ventricular overload.

Cardiac silhouette volumes were compared statistically to left ventricular end-diastolic volume, left ventricular total volume, and left heart volume in all four groups. The closest correlations were noted when cardiac silhouette volumes were compared to LHV, in groups I and II. The cardiothoracic ratio was compared statistically to LHV in all four groups. The correlations were significant in group I but not close in group II and not significant in groups III and IV.

The cardiac volume determination can be accurately carried out using biplane angiocardiography, while a common clinical method for assessing cardiac enlargement is the use of chest X ray films.

These various angiocardiographic parameters for assessing cardiac enlargement were compared statistically to cardiac silhouette volume or cardiothoracic ratio obtained from plain chest X ray films of infants and children with a spectrum of heart disease.

The results of this report should assist in establishing quantitatively assessment of heart enlargement from plain chest X ray films.

MATERIALS AND METHODS

The patients for the study consisted of 173 who had been diagnosed following cardiac catheterization and angiocardiography in Department of Pediatrics, Kyoto University. No patient had pericardial disease or effusion.

The patients were subsequently separated into four groups on the basis of

The following abbreviations are used : CVS, cardiac silhouette volume ; LVTV, left ventricular total volume (left ventricular end-diastolic volume plus left ventricular mass) ; LHV, left heart volume (left ventricular end-diastolic volume plus left ventricular mass plus left atrial maximal volume)

TABLE I. *Classification of the 173 Analized Cases*

Group I Diagn.	Cases	II Diagn.	Cases	III Diagn.	Cases	IV Diagn.	Cases
PMD	9	MI	12	VSD	29	a :	
MCLS	6	PMD+MI	5	VSD+PS	4	TF	24
NHD	5	SASS	2	VSD+MI	3	TF+PDA	2
misc.	4	misc.	9	VSD+PDA	3	TA	8
				VSD+other	4	TGA	7
				ASD sec.	9	TGA+PA	3
				ASD pr.	5	TAPVC	2
				CA-VC	2	PA	2
				PDA	2	misc.	4
				misc.	2	b :	
						PS	3
						post TF	2
						PI	1
Total	24		28		63		58

Abbreviations

PMD : primary myocardial disease
MCLS : mucocutaneous lymphnode syndrome
NHD : no heart disease
misc. : miscellaneous disease
MI : mitral insufficiency
SASS : supraaortic stenosis syndrome
VSD : ventricular septal defect
PS : pulmonary stenosis
PDA : patent ductus arteriosus
ASD sec. : atrial septal defect ostium secundum type
ASD pr. : atrial septal defect ostium primum type
CA-VC : common atrioventricular canal
TF : tetralogy of Fallot
TA : tricuspid atresia
TGA : transposition of the great arteries
PA : pulmonary atresia
TAPVC : total anomalous pulmonary venous connection
PS : pulmonary stenosis
PI : pulmonary insufficiency

ventricular overload pattern as listed in Table I. The first group consisted of patients without valvular disease and shunt. The second group had a left ventricular overload pattern without left to right shunt. The third group consisted of those having biventricular overload pattern with left to right shunt. The fourth group had a right ventricular overload pattern : subgroup "a" with right to left shunt, subgroup "b" with pulmonary stenosis or pulmonary insufficiency.

Biplane angiocardiography at six exposures in seconds with power injection of angiografin into a left heart chamber was carried out.

Left ventricular end-diastolic volume was calculated from the biplane angiocardiographic films by the method of Dodge *et al.*(1). Left ventricular mass was calculated from the biplane angiocardiographic films by the method of Rackley *et al.* (2). Left atrial maximal volume was calculated by the method of Sauter *et al.* (3).

Calculation of cardiac silhouette volume required posteroanterior and lateral roentgenograms. Three measurements were taken in centimeters. The length diameter (L) was measured from the junction of the superior vena cava and

right atrium to the cardiac apex. The broad diameter (B) was taken from the junction of the right atrium and the diaphragm and the junction of the pulmonary artery and left atrial appendage. The third dimension (D) represented the greatest horizontal depth of the cardiac shadow.

Calculation of the cardiac silhouette volume was done based on the formula:

$$V = K \times B \times D \times L$$

The constant K represented the product of an ellipsoid area factor and correction factor for magnification of the cardiac image.

The value of K will therefore vary with different focal-film distances and the distance of the heart from the film. The following K values were listed for the focal-film distances most commonly used(4):

200cm $K = 0.42$
150 cm $K = 0.39$
100 cm $K = 0.38$

RESULTS

The correlation coefficients between the cardiac silhouette volume and the left ventricular end-diastolic volume in the four groups are shown in Table II.

TABLE II. *Correlation Coefficients between the Cardiac Silhouette Volume and the Left Ventricular End-diastolic Volume in Each Group*

	I	II	III	IV
Cases	23	28	63	58
Correlation coefficient	0.71	0.81	0.88	0.78

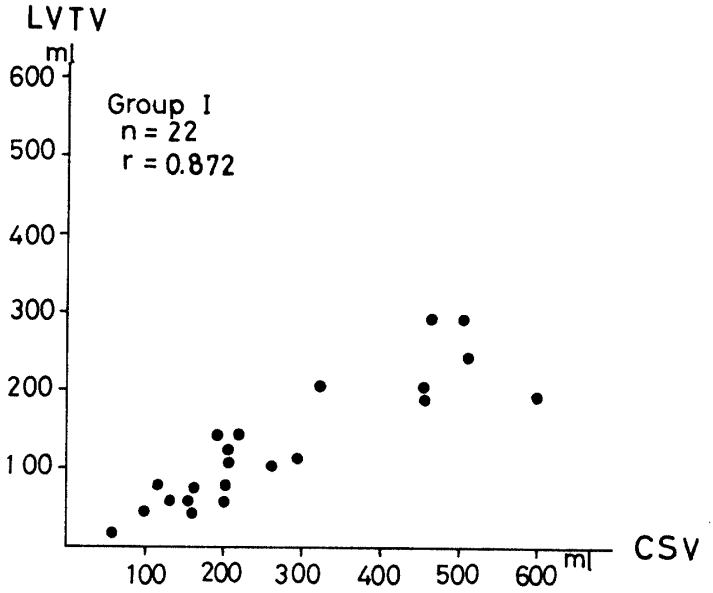

Fig. 1. Relationship between the cardiac silhouette volume and the left ventricular total volume in group I.

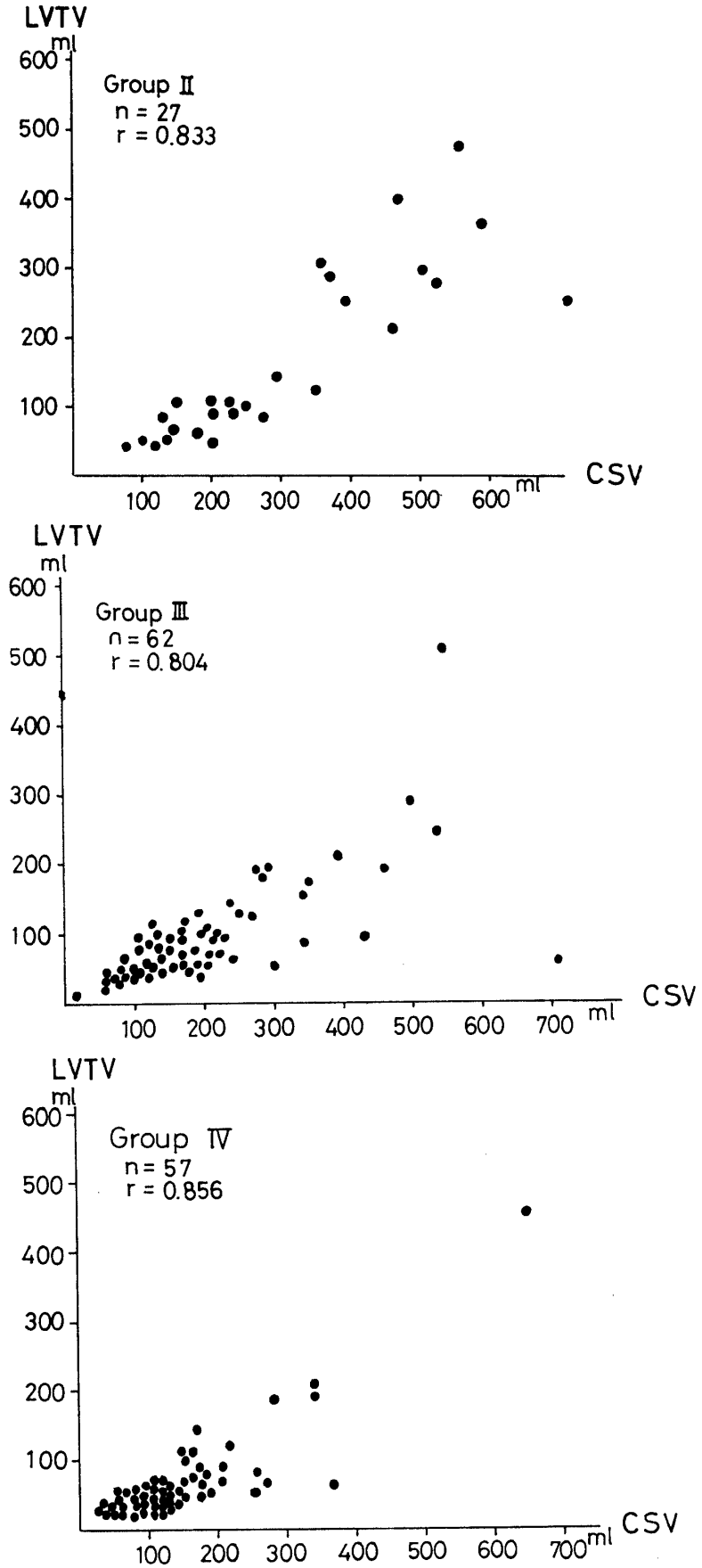

Fig. 2. Relationship between the cardiac silhouette volume and the left ventricular total volume in groups II, III and IV.

Figs. 1 and 2 showed the results of the cardiac silhouette volume compared statistically to the left ventricular total volume (left ventricular end-diastolic volume plus left ventricular mass) in the four groups. The correlations were noted ; r = 0.872 in group I, r = 0.833 in group II, r = 0.804 in group III, r=0.856 in group IV.

Figs. 3 and 4 showed the results of the cardiac silhouette volume compared statistically to the left heart volume (left ventricular end-diastolic volume plus left ventricular mass plus left atrial maximal volume) in the four groups. The correlations were noted in group I (r=0.925) and in group II (r=0.980),

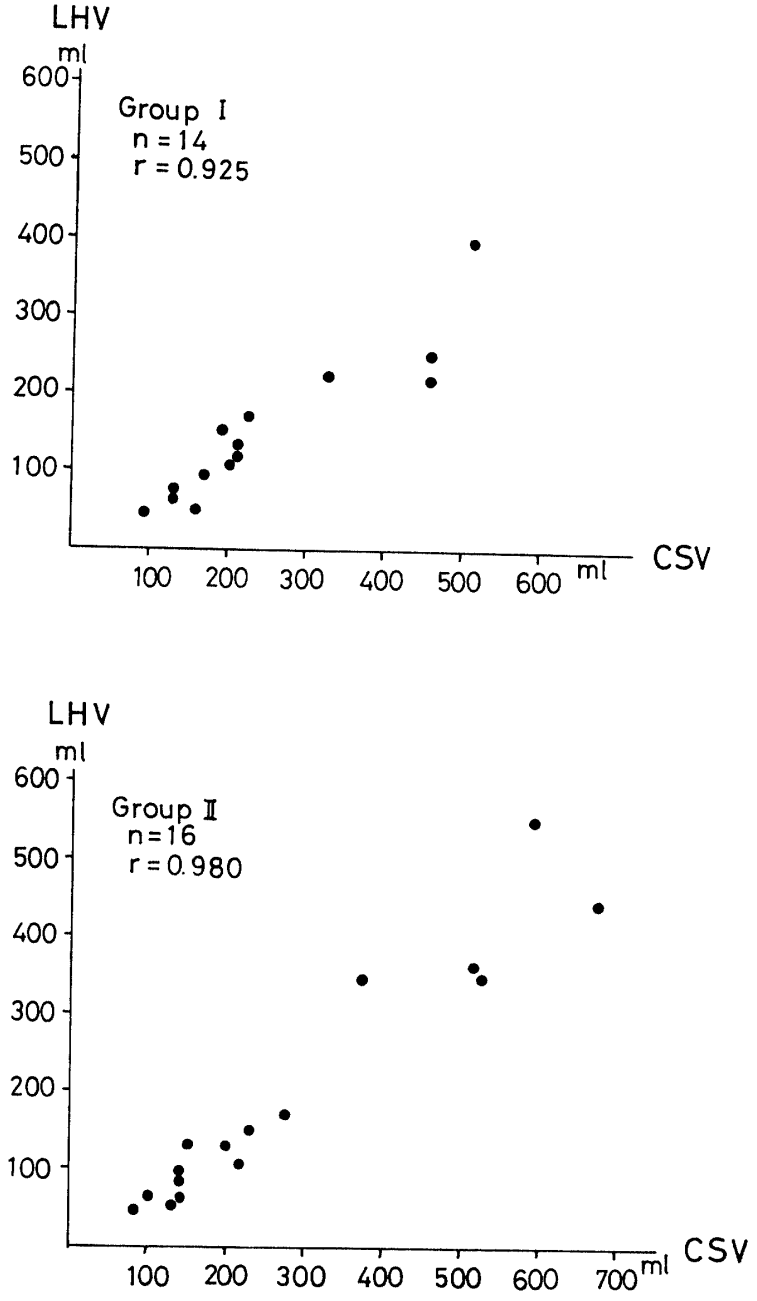

Fig. 3. Relationship between the cardiac silhouette volume and the left heart volume in groups I and II.

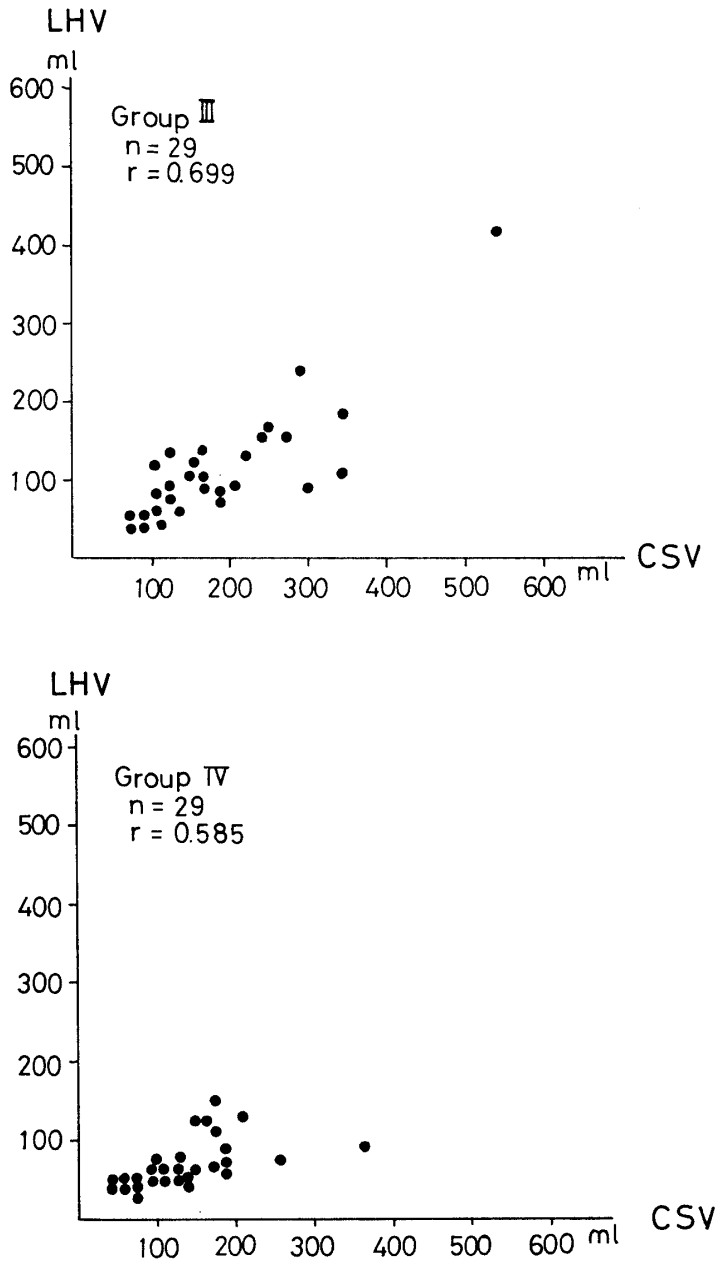

Fig. 4. Relationship between the cardiac silhouette volume and the left heart volume in groups III and IV.

but there were slight correlations in group III ($r = 0.699$) and in group IV ($r = 0.585$).

The closest correlations were noted when cardiac silhouette volumes were compared to the left heart volume in groups I and II. The regression equation was as follows:

$$y = 0.79x - 28.0 + 45.9$$

The comparison between the cardiothoracic ratio and the left heart volume index (left heart volume/body surface area) in the four groups is shown in Table III. The correlation was noted in group I ($r = 0.808$), but there was

TABLE III. *Correlation Coefficients between the Cardiothoracic Ratio and the Left Heart Volume Index in Each Group*

	I	II	III	IV
Cases	9	13	25	27
Correlation coefficient	0.808	0.554	0.183	0.261

a lower correlation in group II ($r = 0.554$) and an insignificant correlation in group III ($r = 0.183$) and in group IV ($r = 0.261$).

DISCUSSION

Radiologic estimation of heart size is one of the most frequently employed of all diagnostic procedures in the evaluation of the cardiac patients seen in pediatrics. The cardiac silhouette volume measurement has been used widely in Scandinavia. The upper limits of normal for infants and children were reported by Eek(6).

In our data, there was evidence that the cardiac silhouette volume correlated more closely with left heart size than did the cardiothoracic ratio. This was already described by Glover *et al.* (5) who attributed this to the fact that an anteropostero measure of heart size was included in the cardiac silhouette volume but not in the cardiothoracic ratio calculation. As shown in Table III, when the patient had biventricular overload or right ventricular overload, the correlation between the cardiothoracic ratio and left heart size was not significant.

The relationship between the cardiac silhouette volume and the left heart volume has also been described by Glover *et al.* (5) who reported various heart diseases which had been separated into categories of pressure load, volume load, combined load, and myocardial disease.

As shown in Figs. 3 and 4 when the patient was without biventricular overload or right ventricular overload, the correlation between the cardiac silhouette volume and left heart volume was quite significant, but when the patient had a biventricular overload or right ventricular overload this correlation, albeit significant was not so close. This might be due to the fact that left ventricular volume, left ventricular mass, and left atrial maximal volume reflected closely the cardiac silhouette volume when the patient revealed no biventricular overload or right ventricular overload in infancy and childhood.

We thank the staff of the Department of Pediatrics, Kyoto University, for kind cooperation during examinations.

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