ACTA MED PORT 1: 457, 1979

ATRIAL SEPTAL DEFECT — ECHOCARDIOGRAPHIC ASSESSMENT BEFORE AND AFTER SURGICAL REPAIR *

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SUMMARY

Twenty-two patients with atrial septal defect (ostium secundum type and sinus venosus) were studied by echocardiography before and after surgery. The sizes of the various heart chambers — right and left ventricles, left atrium and aortic root — and the interventricular septum and the left ventricular posterior free wall (motion and thickness) were analysed and compared in the pre and postoperative period. A significant reduction in size of the right ventricle and a *normalization* of the left ventricular dimension in the early postoperative evaluation was found. The paradoxical motion of the interventricular septum seen in the preoperative period showed an early trend toward normalization. The changes before and after surgery are discussed, particularly for the interventricular septum.

Surgical correction of ostium secundum atrial septal defect gives excelent results and has low mortality even in patients in their forties and fifties with congestive heart failure (Cohn et al 1967; Epstein et al 1973; Costa et al 1978). However, in a high number of cases there are persistent anatomic and functional cardiac abnormalities which are not entirely explicable (Tikoff et al 1969; Davies et al 1970; Popio et al 1975; Radtke et al 1976). Echocardiography, a non invasive method, is extremely useful both in the diagnosis of this type of heart disease (Popp et al 1969; Diamond et al 1971; Meyer et al 1972; Tajik et al 1972; Kerber et al 1973; Hagan et al 1974) and in the evaluation of left ventricular function after its surgical correction (Laurenceau and Dumesnil 1976; Radtke et al 1976; Pearlman et al 1978).

We studied a group of patients with ostium secundum atrial septal defect or sinus venosus defect, pre and postoperatively, by means of echocardiography comparing the sizes of the various heart chambers and the thickness and motion of the interventricular septum and of the posterior wall of the left ventricle. The significance of the variations found is discussed.

MATERIAL AND METHODS

Pre and postoperative echocardiograms of 22 patients with ostium secundum atrial septal defect (21 cases) and sinus venosus (1 case) were studied. All the patients un-

* Part of this study was presented at the II Portuguese Congress of Cardiology — Alvor, 1977.

Received: 31 May 1979

derwent surgical correction under cardiopulmonary bypass at the Department of Medico--Surgical Cardiology of the Santa Maria Hospital between July 1974 and April 1977. In 18 cases the atrial septal defect was closed with plain stitches and a patch was used in 4 cases. In one case it was found necessary correct a cleft of the mitral valve and in one case the echocardiographic diagnosis of mitral valve prolapse was confirmed during surgery. There were no abnormalities of the tricuspid valve resulting in regurgitation in any patient (Meyer et al 1972; Tajik et al 1972; Laurenceau and Dumesnil 1976). The pericardium was always carefully closed. There were 13 females and 9 males and the mean age was 28 years at the time of surgery (ranged from 10 to 54 years). Preoperatively 20 patients were in sinus rhythm and 2 in atrial fibrillation and postoperatively, when echocardiographic studies were done, 19 had sinus rhythm and 3 atrial fibrillation. In 15 patients echocardiograms were done during the first 4 weeks after surgery (early evaluation) and in the others between the first and the 17th month.

Echocardiographic Studies — All pre and postoperative studies in the patients were made with an echocardiograph (Ekoline 20-A, Smith-Kline Instruments) and with a transducer focused at 7.5 cm, 2.25 MHz with a repetition rate of 1000/ /second. The tracings were obtained with a Honeywell 1856 strip-chart recording unit on a Kodak Linagraph type 1895 photographic paper, with a speed of 20 and 50 mm/ /second. The patients were examined while recumbent and partly turned into the left lateral position. The transducer was placed in the 3rd to the 5th left intercostal space near the sternal border. After identifying the anterior leaflet of the mitral valve the transducer was given a slight infero-lateral rotation so that we could obtain a simultaneous, clear and continuous visualization of the interventricular septum and the endocardium of the posterior wall of the left ventricle, at a plane situated just below the level of the mitral valve tip. The aorta and the left atrium were identified after a medial and superior rotation of the transducer.

Measurements (Fig. 1) — Right ventricular dimension (RVD) was measured at the onset of the first deflection of the QRS complex of a simultaneous electrocardiographic tracing (ECG), from the right side of the interventricular septum to the anterior wall of the right ventricle which is found at a distance of about 0.5 cm of the distal echoes of the thoracic wall (Popp et al 1969; Diamond et al 1971). Left ventricular dimension (LVD) was measured from the left endocardium of the septum to the endocardium of the left ventricle posterior free wall, at end-diastole. The distance from the anterior wall of the right ventricle to the middle of the thickness of the interventricular septum (RV-S) and total cardiac dimension (TCD) from the right ventricular epicardium to the left ventricular epicardium (Pearlman et al 1976) were also measured at end-diastole. Aortic root dimension (ARD) was measured at the onset of the QRS complex from the anterior aortic wall to the posterior aortic wall and left atrial dimension (LAD) was measured at the end of the T wave of the ECG from the posterior left atrial wall to the posterior aortic root wall. Intterventricular septal thickness was measured both at end-diastole (Sd) and systole (Ss) and its motion was evaluated and classified as normal (N), type A or type B according to the description of Popp et al (1969) and Diamond et al (1971). Left ventricular posterior wall thickness (PW) was also measured at end-diastole as well as the range of its systolic motion (PWM). All the measurements were made by two diferent investigators with an average of 4 to 6 measurements, depending on whether there was a sinus rhythm or atrial fibrillation.

The measurements — RVD, LVD, ARD and LAD — were expressed as index (cm/m^2 of body surface). The preoperative values were compared with postoperative values and also with those found in a group of 20 normal subjects (13 males and 7 females, aged between 14 and 39 years). The relationship RV-S/TCD indicating the relative position of the interventricular septum in the heart at end-diastole (Pearlman et al 1976) and the systolic thickness of the interventricular septum expressed as percentage $(\frac{Ss - Sd}{Sd} \times 100)$ (Assad-Morell et al 1974) were also evaluated and compared.

Paired Student's t test and linear regression analysis were used for statistical comparison of the data.

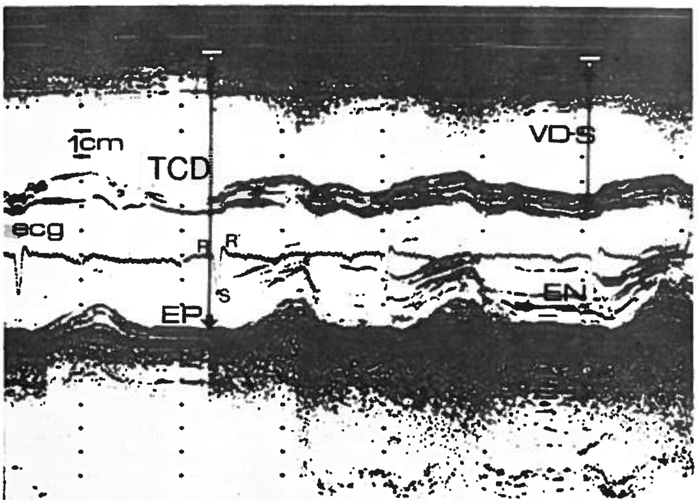

Fig. 1 — *Echocardiogram in atrial septal defect. Site of measurements. VD-S = distance from right ventricular epicardium to mid-septum; TCD = total cardiac dimension; EN = endocardial surface of left ventricular posterior wall; EP = left ventricular epicardium; ecg = electrocardiogram*

RESULTS

Echocardiographic data of 22 patients with atrial septal defect before and after surgery are presented on Table I and II.

Right and left ventricular dimensions (index) and total cardiac dimension

Right ventricular dilatation was present in every patient before operation — 3.0 ± ± 0.6 cm/m^2 (normal, 1.2 ± 0.2 cm/m^2; $P < 0.001$) — and decreased after operation to 2.0 ± 0.5 cm/m^2 ($P < 0.001$). Normalization was achieved only in three cases (15 %). For the group of the fifteen patients studied in the early postoperative period the reduction in size of the right ventricle was also highly significant (3.0 ± 0.5 to 2.2 ± 0.4 cm/m^2; $P < 0.001$) (Fig. 2).

Left ventricular internal dimension was decreased before operation — 2.5 ± 0.3 cm/m^2 (normal, 2.9 ± 0.3 cm/m^2; $P < 0.001$) — and normalized after operation (3.0 ± 0.3 cm/m^2). The variation was from 2.6 ± 0.2 cm/m^2 to 3.0 ± 0.3 cm/m^2 ($P < 0.001$) in the group of patients studied in the early postoperative period.

Preoperative total cardiac dimension was 9.5 ± 1.2 cm and decreased to 9.0 ± ± 1.1 cm after operation ($P < 0.001$) (Fig. 3), as a consequence of the relative reduction in the size of the right ventricle.

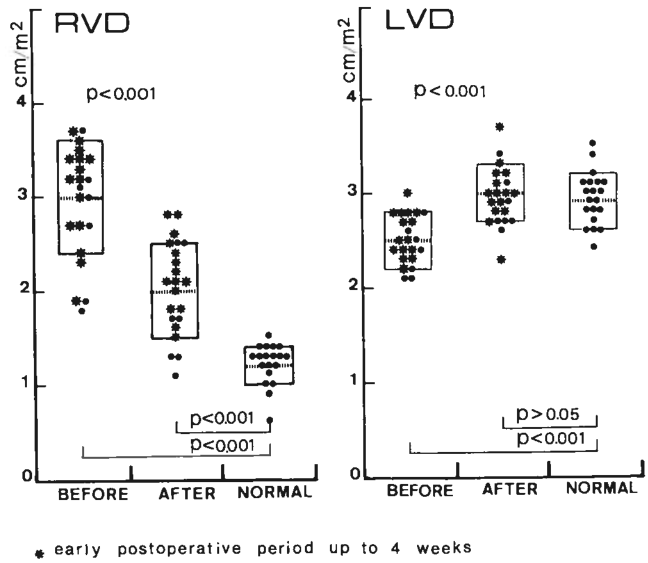

Fig. 2 — *Comparison of right ventricular diastolic dimension index (RVD) and left ventricular internal dimension (LVD) in 22 patients with atrial septal defect, before and after surgical repair, with a group of normal subjects*

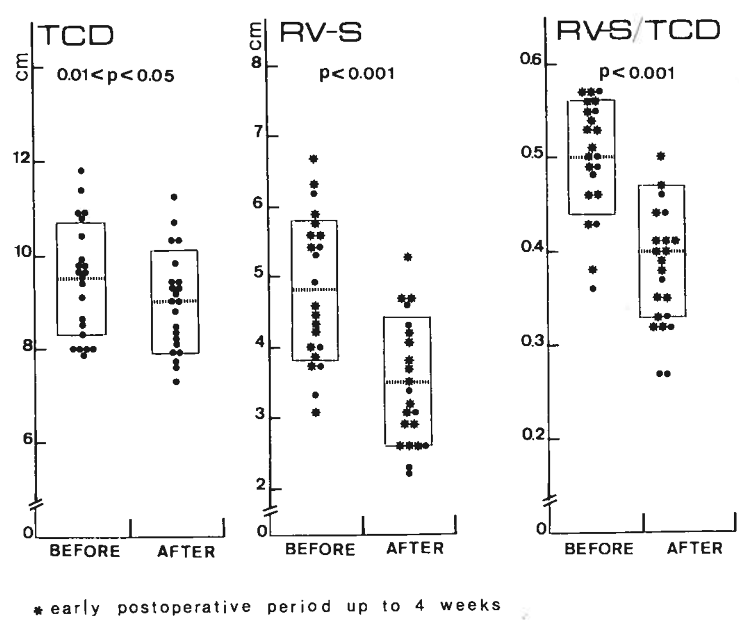

Fig. 3 — *Total cardiac dimension (TCD), distance from right ventricular epicardium to mid-septum (RV-S) and RV-S/TCD ratio in 22 patients with atrial septal defect, before and after surgery*

Interventricular Septum

Preoperatively, abnormal septal motion was present in every patient. In seventeen patients it was paradoxical type A and in five paradoxical type B. Postoperatively, septal motion was paradoxical type A in four patients, paradoxical type B in five and normal in thirteen (59 %). An early normalization occurred in eight patients (postoperative follow-up up to four weeks). All of the three patients with a normal right ventricular size (cases 20, 21 and 22) had a normal septal motion after operation.

The ratio RV-S/TCD was 0.50 ± 0.06 before operation and reduced to 0.40 ± ±0.07 after operation ($P < 0.001$) (Fig. 3). The ratio RV-S/TCD in the nine cases with abnormal septal motion after operation was also compared with the thirteen cases which had normalized the septal motion. In the first group, the mean value for that ration was 0.41 ± 0.06 (range, from 0.35 to 0.47) and in the second group, the mean value was 0.36 ± 0.06 (range, from 0.30 to 0.42), which was significantly lower ($P < 0.05$).

The end-diastolic septal thickness was within the normal range, before and after surgery. The systolic septal thickness determined in 18 patients was 33 ± 19 % preoperatively, and 46 ± 17 %, postoperatively.

Left ventricular posterior wall

Left ventricular posterior wall motion was increased before operation — 1.5 ± ± 0.3 cm (normal, 1.2 ± 0.2 cm; $P < 0.001$) — and continued to be abnormal after operation — 1.5 ± 0.3 cm (Fig. 4). The end-diastolic wall thickness was normal pre and postoperatively.

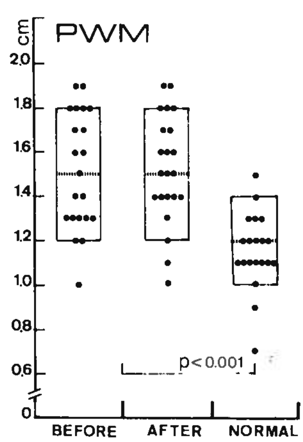

Fig. 4 — *Comparison of left ventricular posterior wall motion in 22 patients with atrial septal defect, before and after surgery, with a group of normal subjects*

Left atrial and aortic root dimensions

The left atrial dimension was increased significantly before and after operation, respectively, 2.3 ± 0.5 cm/m² and 2.4 ± 0.6 cm/m² (normal, 1.7 ± 0.3 cm/m²; $P < 0.001$).

The aortic root dimension was normal and didn't suffer variations with surgery (Fig. 5).

Table 1

Clinical and Echocardiographic Data in 22 Patients with ASD Before and After Surgical Repair

Case n.º	Age Sex	Rhythm Pre	Rhythm Post	Postop. Interval (days or months)	Septal Motion Pre	Septal Motion Post	RVD Index (cm/m²) Pre	RVD Index (cm/m²) Post	LVD Index (cm/m²) Pre	LVD Index (cm/m²) Post	TCD (cm) Pre	TCD (cm) Post	RV-S (cm) Pre	RV-S (cm) Post	RV-S/TCD Pre	RV-S/TCD Post
1	25 F	S	S	17 d.	A	N	3.0	2.2	2.5	3.0	8.0	4.5	4.5	3.2	0.56	0.38
2	54 M	F	F	15 d.	A	A	3.4	2.8	2.2	2.8	11.8	11.2	6.7	5.3	0.56	0.47
3	20 M	S	S	15 d.	B	N	2.7	1.6	2.8	3.0	9.0	9.0	4.4	2.9	0.46	4.32
4	24 F	S	S	15 d.	A	B	3.7	2.3	2.7	3.3	10.4	9.8	5.6	4.1	0.53	0.41
5	14 F	S	S	21 d.	B	N	1.9	1.8	2.8	2.8	8.0	8.2	3.1	2.9	0.38	0.35
6	10 M	S	S	14 d.	A	A	3.3	2.1	2.8	3.7	8.0	7.7	4.0	2.6	0.50	0.33
7	21 F	S	S	20 d.	A	N	3.5	2.1	2.3	2.9	9.8	8.8	5.4	3.5	0.55	0.39
8	11 M	S	S	22 d.	A	N	2.3	1.8	2.7	3.2	7.9	7.3	3.9	2.6	0.49	0.35
9	28 M	S	S	21 d.	A	B	3.2	2.6	2.4	3.0	10.7	10.7	5.7	4.7	0.53	0.44
10	46 F	S	S	28 d.	A	N	3.2	2.0	2.4	2.7	11.4	9.3	5.9	3.8	0.51	0.41
11	38 F	S	S	18 d.	A	B	3.4	2.5	2.4	3.0	10.9	10.3	6.3	4.2	0.57	0.40
12	27 F	S	S	28 d.	A	B	2.7	2.1	2.8	2.9	9.9	9.0	4.6	3.7	0.46	0.41
13	16 M	S	S	2 M.	B	A	1.8	1.7	2.8	3.1	9.1	9.4	3.3	3.1	0.36	0.33
14	12 F	S	S	16 d.	A	N	3.6	2.4	2.5	3.1	8.0	7.6	4.3	3.1	0.54	0.40
15	24 F	S	S	14 d.	A	N	2.4	1.5	3.0	3.2	8.5	7.9	3.7	2.6	0.43	0.32
16	48 M	S	S	2 M.	B	N	3.1	1.7	2.6	2.6	10.9	9.1	5.4	3.4	0.49	0.37
17	43 M	F	F	18 d.	A	A	3.4	2.8	2.3	2.3	9.8	9.4	5.6	4.7	0.57	0.50
18	22 F	S	S	6 M.	A	N	3.2	2.5	2.5	2.7	9.7	9.3	4.9	4.3	0.50	0.46
19	46 F	S	S	17 M.	A	B	3.7	2.5	2.1	2.7	10.8	10.3	6.2	4.6	0.57	0.44
20	23 F	S	S	8 M.	B	N	1.9	1.3	2.2	2.7	8.6	8.1	3.7	2.6	0.43	0.32
21	47 F	S	S	12 M.	A	N	3.0	1.1	2.1	2.9	9.5	8.3	5.3	2.3	0.55	0.27
22	15 M	S	F	1 M.	A	N	2.7	1.3	2.4	3.4	8.3	7.9	4.0	2.2	0.48	0.27
Mean ± SD	28	...	...	...	...	...	3.0 ± 0.6	2.0 ± 0.5	2.5 ± 0.3	3.0 ± 0.3	9.5 ± 1.2	9.0 ± 1.1	4.8 ± 1.0	3.5 ± 0.9	0.50 ± 0.06	0.40 ± 0.07

ASD = atrial septal defect; RVD = right ventricular dimension; LVD = left ventricular internal dimension; TCD = total cardiac dimension; RV-S = distance from right ventricular epicardium to mid-septum; RV-S/TCD = = septal position ratio N = normal; A = Abnormal type A; B = abnormal type B; Pre = preoperative; Post = = postoperative.

Table 2

Clinical and Echocardiographic Data in 22 Patients with ASD Before and After Surgical Repair

Case n.°	Septum (d) (cm)		Septum (s) (cm)		PW (d) (cm)		PWM (cm)		LAD Index (cm/m²)		ARD Index (cm/m²)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	0.9	0.7	1.1	1.2	0.8	0.8	1.3	1.4	3.0	2.9	1.9	1.6
2	0.9	0.7	1.0	1.2	0.7	0.8	1.8	1.6	3.1	3.2	1.7	1.8
3	0.9	1.1	1.3	1.4	0.7	0.9	1.2	1.5	1.9	2.0	1.9	1.5
4	0.9	1.0	1.3	1.5	0.7	0.8	1.8	1.9	2.6	2.8	1.9	1.8
5	1.0	0.8	1.4	1.3	0.9	0.9	1.7	1.1	2.2	1.7	1.6	2.2
6	1.0	1.0	0.9	1.0	0.6	0.6	1.5	1.4	2.4	1.9	2.1	2.3
7	0.8	1.1	1.3	1.8	0.7	0.6	1.8	1.8	2.1	2.9	1.4	2.0
8	0.8	0.8	0.9	1.3	0.7	0.6	1.3	1.3	1.7	1.7	2.0	2.0
9	0.9	0.8	1.2	1.2	0.8	0.8	1.2	1.6	2.5	2.5	1.9	2.0
10	1.0	0.8	—	—	1.1	0.9	1.7	1.0	2.1	3.0	2.1	2.0
11	1.0	0.9	1.1	1.0	0.8	0.8	1.4	1.4	2.4	2.3	1.4	2.0
12	0.9	1.0	1.1	1.2	0.7	0.9	1.3	1.2	1.7	1.9	1.9	1.9
13	0.9	0.9	1.2	1.4	0.8	0.8	1.3	1.8	1.7	2.2	1.7	2.2
14	0.8	0.8	1.1	1.3	0.7	0.8	1.0	1.4	3.0	3.6	1.8	1.9
15	1.0	1.0	1.3	1.3	0.7	0.7	1.4	1.5	2.4	2.5	2.0	2.3
16	0.7	1.0	1.3	1.6	0.8	0.8	1.9	1.4	2.3	1.6	1.7	1.7
17	0.9	0.9	—	—	0.8	0.9	—	1.5	3.6	3.4	1.9	1.9
18	0.9	1.0	0.9	1.1	0.7	0.9	1.6	1.6	2.1	2.3	1.8	2.1
19	0.8	1.0	1.1	1.2	0.7	0.7	1.8	1.7	2.3	2.2	1.5	1.6
20	0.9	0.8	1.1	1.1	0.9	0.7	1.6	1.7	1.4	1.9	1.1	1.4
21	1.0	1.1	1.3	1.6	0.7	0.6	1.3	1.8	2.3	2.3	1.9	1.7
22	1.0	0.9	1.1	1.4	0.8	0.8	1.9	1.9	2.3	1.7	2.0	1.7
Mean ± S. D.	0.9 ± 0.1	0.9 ± 0.1	1.2 ± 0.1	1.3 ± 0.2	0.8 ± 0.1	0.8 ± 0.1	1.5 ± 0.3	1.5 ± 0.3	2.3 ± 0.5	2.4 ± 0.6	1.8 ± 0.3	1.9 ± 0.3

ASD = atrial septal defect; PW = left ventricular posterior wall thickness; PWM = left ventricular posterior wall motion; LAD = left atrial dimension; ARD = aortic root dimension; d = end-diastole s = systole; Pre = preoperative; Post = postoperative.

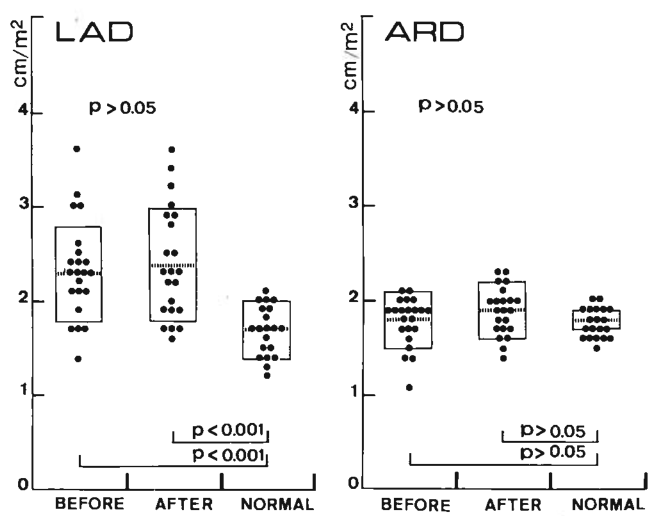

Fig. 5 — *Comparison of left atrial dimension index (LAD) and aortic root dimension index (ARD) in 22 patients with atrial septal defect, before and after surgical repair, with a group of normal subjects*

DISCUSSION

The echocardiographic diagnosis of atrial septal defect (ostium secundum type or sinus venosus) is based on the recognition of a right ventricular volume overload together with some abnormalities of the mitral valve (Diamond et al 1971; Kamigaki and Goldschlager 1972; Meyer et al 1972; Tajik et al 1972; Kerber et al 1973).

The right ventricular volume overload implies a right ventricular enlargement together with an abnormal motion of the interventricular septum and can be found also in other similar hemodynamic conditions e. g. tricuspid regurgitation and pulmonary valve insufficiency (Tajik et al 1972; Kerber et al 1973). The abnormal motion of the interventricular septum is its systolic approach to the anterior wall of the right ventricle and its diastolic approach to the posterior wall of the left ventricle. As the motion is opposite in direction to the normal one it has been termed paradoxical motion, and classified as type A or type B according to its degree (Popp et al 1969; Diamond et al 1971). The systolic septal thickness usually found in the majority of ASD proves that there is septal contraction and that it is not merely a passive motion (Radtke et al 1976). The explanation that the normal septal motion, that is concentric to the free wall of the left ventricle, continues, and that the apparently paradoxical septal motion is due to an exaggerated anterior movement of the entire heart during mid and end-systole caused by an increased systolic right ventricular volume is not acceptable because the abnormal septal motion starts with the ventricular systole (Meyer et al 1972). One of the theories proposed to explain the paradoxical septal motion is that in any heart disease with a diastolic overload of the right ventricle the abnormal distended wall of the right ventricle and the interventricular septum, due to a higher diastolic volume of blood, contract concentrically in the following systole, and so the septum takes an opposite direction to the normal one (Diamond et al 1971). Pearlman et al (1976 and 1978) having found that a significant number of patients maintained the abnormal septal motion after the closure of the ASD, and having excluded a persistent left-to-right shunt or a tricuspid insufficiency, proposed an alternative hypothesis: the systolic septal motion would be related to its position at end-diastole to the center of gravity of the heart, considered in its total mass of blood and muscle; thus, the direction and magnitude of systolic septal motion would be done towards the preponderant ventricular mass. This theory could explain the paradoxical septal motion in certain patients with pulmonary valve stenosis, primary pulmonary hypertension and tetralogy of Fallot without an associated tricuspid or pulmonary insufficiency and excluding an abnormal electric septal activation (Assad-Morel et al 1974). Our results indicate a highly significant reduction after surgery of the right ventricular dimensions. This reduction was early and ranged from 20 to 50 %. The abnormal septal motion persisted postoperatively in those patients who continued to have a significant preponderance of the right ventricular mass, with a higher probability of a paradoxical septal motion when the RV-S/TCD relation was equal to or higher than 0.42. As in our cases there was no evidence of a persisting left-to-right shunt or of an associated tricuspid or pulmonary valvular insufficiency, our results seem to agree with the theory proposed by Pearlman et al.

It is interesting that in a group of 10 patients who underwent surgery for ASD (O.S.) and whose age range was 10 to 52 years (average 23) with postoperative echocardiographic evaluation between 1 and 18 years (average 8), right ventricular enlargement persisted in 9 out of 10 cases and paradoxical septal motion was noticed in 50 % of the patients. These patients were not included in this study because preoperative echocardiograms were not done. There is the same tendency to a persistence of the right ventricular enlargement and the normalization of the motion of the interventricular septum does not seem related to the duration of the postoperative follow-up study or to the patient's age at the time of operation, at least within the range of age of our patients.

Various abnomalities of left ventricular function found in ASD have been considered due to a reduced left ventricular preload (Davies et al 1970; Popio et al 1975). In our cases we found a reduced left ventricular diastolic dimension before surgery which became normal after surgical correction and there was no significant variation of the end-diastolic thickness of the left ventricular posterior wall. We also noticed that before surgery the posterior wall contracted more vigorously as if to compensate for the interventricular septum not contributing to the left ventricular systole. However, even after surgical correction this persisted in 54 % of the cases with a *normalization* of septal motion. This fact requires a more detailed study in this type of heart disease of the myocardial distensibility and contractility.

There are also certain abnormalities in the function of the mitral valve, in particular of the posterior leaflet (Kamigaki and Goldschlager 1972), excluding the proven cases of prolapse, that have been partly explained by changes in the left ventricular geometry and mechanics. This would contribute to an abnormal opening of the posterior commissure of the mitral valve which would result in fibrosis of this area (wear and tear type of lesions) (Okada et al 1969). Knowing the anatomic importance of the continuity of the endocardium of the left atrium and the posterior leaflet of the mitral valve and the finding in our cases of an enlarged left atrium, the importance of this factor as a cause of the abnormal motion of the mitral valve in ASD remains open to discussion.

Acknowledgments

We gratefully acknowledge the assistance of Dr. Godinho, from Isotopic Laboratory, I.P.O., in performing statistical analyses.

RESUMO

Compararam-se os ecocardiogramas pré- e pós-operatórios de 22 doentes operados a comunicação interauricular (ostium secundum e sinus venosus). O estudo pós-operatório foi realizado durante as primeiras quatro semanas (avaliação precoce) em 15 doentes e entre o primeiro e décimo sétimo mês nos restantes. Fez-se uma análise da variação das dimensões das câmaras ventriculares, da aurícula esquerda e da raiz da aorta, e estudou-se o septo interventricular e a parede livre do ventrículo esquerdo, comparando-se os resultados obtidos no pré- e pós-operatório com um grupo de 20 normais. Verificou-se no pós- operatório (imediato e tardio) uma redução significativa da dimensão do ventrículo direito, que se encontrava aumentada pré-operatoriamente em todos os casos (2.0 ± 0.5 vs 3.0 ± 0.6 cm/m^2 de superfície corporal, $p < 0.001$) (normal, 1.2 ± 0.2 cm/m^2). Em relação à dimensão do ventrículo esquerdo houve uma normalização significativa a partir de valores inferiores ao normal obtidos no pré-operatório (3.0 ± 0.3 vs. 2.5 ± 0.3 cm/m^2, $p < 0.001$) (normal, 2.9 ± 0.3 cm/m^2). O movimento do septo interventricular, anormal em todos os doentes no pré-operatório, passou a fazer-se em direcção normal no pós-operatório em 13 doentes (59 %), havendo normalização em 8 dos 15 doentes estudados precocemente. Em relação a outros parâmetros

— espessura septal, espessura e excursão da parede posterior do ventrículo esquerdo, dimensões da aurícula esquerda e da raiz da aorta — não encontrámos variações significativas entre as determinações pré- e pós-operatórias. Contudo, quer para a excursão da parede livre do ventrículo esquerdo quer para a dimensão da aurícula esquerda, encontrámos valores significativamente aumentados no pré-operatório-1.5 ± 0.3 cm (normal, 1.2 ± 0.2 cm) e 2.3 ± 0.5 cm/m² (normal, 1.7 ± 0.3 cm/m²), respectivamente. Discute-se o significado das alterações encontradas, com particular relevância para o movimento do septo interventricular, sublinhando-se a provável importância na sua génese das dimensões relativas do ventrículo direito e esquerdo.

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