ORIGINAL ARTICLE

Secundum Atrial Septal Defect Before and After Surgery

by

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Abstrack

Twenty patients with secundum atrial septal defect, who had undergone open heart surgery were studied retrospectively. Girls were more affected than boys; the sex ratio was 1.5 : 1. Associated cardiac defects were diagnosed in two patients, one with moderate valvular pulmonic stenosis and the other one with small ventricular septal defect.

Typical clinical findings consisted of loud first heart sound, widely fixed split second heart sound and soft ejection systolic murmur at the upper left sternal border were heard in all cases. Mid diastolic murmur due to relative tricuspid stenosis was detected in most cases (75%).

Electrocardiographic findings included right axis deviation, prolonged PR-interval and right atrial enlargement were found in 50%, 15% and 60% of cases, respectively. Incomplete right bundle branch block and right ventricular enlargement were found in all cases, as was cardiomegaly with increased vascular markings were found in all cases. Paradoxical ventricular septal motion and visualization of the atrial septal defect were seen in 95% and 75% of cases, respectively. Cardiac catheterization was performed in 19 patients (95%). The pulmonary-systemic flow ratio (Qp/Qs) ranged from 1.7 to 6.3 (mean 2.9 ± 0.67), and was correlated to the presence of mid diastolic tricuspid flow murmur and paradoxical ventricular septal motion.

Simple closure of the defect was the procedure of choice, but in one patient (5%) pericardial patch was used to close the very large defect. The mortality rate was 10 per cent.

Physical retardation was found in all boys and 50% of girls, before surgery. Body weight percentile increased in most cases (61.1%), while body height percentile increased in only 5.6% of cases, postoperatively. Ejection systolic murmur at the upper left sternal border was still detected in one patient (5.6%). Incomplete right bundle branch block persisted in all cases, while cardiomegaly was still found in 5.6% of cases followed-up six months to five years after surgery. There was no residual left ventricular dysfunction in all cases.

Introduction

Atrial septal defects commonly involve the fossa ovalis and are due to deficiency of the valve or the limbus of the fossa ovalis, fenestration of the fossa ovalis, or combination of these. Since the ostium is generaly enlarged, such defect are commonly called secundum (or ostium secundum) atrial septal defect (Feldt et al., 1983).

Secundum atrial septal defect (ASD 2°) is the third or fourth most common congenital cardiac defect in childhood, accounting for approximately 7 per cent. Most infants with this defect are asymptomatic, and frequently their condition goes undetected until there are of school age. Most patients with a moderate left-to-right shunt are asymptomatic, and those with symptoms usually complain only of mild fatigue and dyspnea. The frequency of fatigue and dyspnea increase in patients with larger shunt, and cardiac failure occasionally occurs (Anthony et al., 1979).

Elective surgical repair is the treatment of choice. The age at which repair is done depends on the experience of the surgeon; however there is no obvious advantage in delaying surgery after the patient reaches 4 or 5 years of age (Graham, 1984). Primary repair of these lesions probably curative in the great majority of cases, but late and unpredictable occurence of residual defects or sequelae of the operation make it advisable to continue regular follow-up clinical evaluation (McNamara and Latson, 1983; Sastroasmoro et al., 1985).

The purpose of this study is to evaluate the physical growth as well as clinical, electrocardiographic, radiographic, and echocardiographic findings of patient with ASD 2° before and after surgery.

Materials and Methods

This retrospective study was conducted on patients with ASD 2°, in whom open heart surgery had been performed in Dr. Cipto Mangunkusumo Hospital, Jakarta from February 1984 to November 1988.

The patients had been under the observation of the Pediatric Cardiology Division, Department of Child Health, University of Indonesia, Dr. Cipto Mangunkusumo Hospital. They were followed-up 6 months to 5 years after operation.

Height and weight measurements were made by an experienced staff, using the same equipment, before and every six month to one year after surgery.

Thorough physical examination was done in every patients. Complete electrocardiogram was recorded in all cases, i.e. standard leads, unipolar limb leads and chest leads V3R, V1–V6. All of electrocardiograms were reviewed and assessed by the writers.

Heart size was evaluated roentgenographically by measuring the cardio-thoracic ratio, i.e. the ratio of the maximum width of the heart to the body thorax at the level of the right diaphragm in postero-anterior view.

M-mode and two-dementional echocardiogram were made in all cases prior to, one week after operation and several months thereafter when indicated; Doppler technique was applied in some patients in whom pulmonary hypertension or pulmonary stenosis was suspected.

Cardiac catheterization was performed in most cases, while in patients with classical physical and non-invasive laboratory findings, cardiac catheterization was not needed prior to surgery.

Usually repair of the atrial septal defect was accomplished by direct approximation of the edge of the defect (simple closure) or using pericardial patch or Teflon in very large defect to achieve closure.

For statistical analysis Fisher's ideal index was used.

Results and Discussion

There were 20 patients with ASD 2° in the study period, consisted of 12 girls and 8 boys (tables 1 and 2). The female to male ratio thus being 1.5 : 1, as is generally to be the case (Behrman and Vaughan, 1987; Madiyono et al., 1981; Nadas and Fyler, 1974; Perloff, 1987).

The age of the patients ranged from $3^{6}/_{12}$ to $13^{9}/_{12}$ years at the time of surgery. The clinical findings and time of the surgery of the patients are depicted in table 1.

Associated cardiac defects were diagnosed in 2 out of 20 patients (10%), one with moderate valvular pulmonic stenosis and the other one with small ventricular septal defect.

Growth retardation occurred in a large proportion of children with congenital heart disease (Feldt et al., 1969; Suoninen, 1971; Chan et al., 1987). Mehrizi and Allan (1962) found that patients without cyanosis were less severely retarded than those with persistent cyanosis. They also concluded that patients with complicated ASD showed marked retardation in both height and weight, whereas those with isolated ASD 2° showed only slight retardation in height, but moderate retardation in weight.

In this series, 14 (70%) and 8 (40%) patients had body weight percentile below 25th and 10th percentile, respectively. In 13 (65%) and in 8 (40%) patients the body height percentile were below 25th and 10th percentile, respectively. Physical retardation was found in all boys and in 6 out of 12 girls (50%); thus boys was in general more retarded than girls. There was no correlation between the degree of the retardation and the severity of the left to right shunt and the size of the communication at atrial level. In tetralogy of Fallot and ventricular septal defect there was a good correlation between the degree of the retardation and the severity of the lesion (Suoninen, 1971; Chan et al., 1987).

Typical auscultatory findings consisted of loud second component of the first sound, widely fixed split of the second heart sound and soft ejection systolic murmur at the upper left sternal border were heard in all cases. Mid diastolic murmur at the lower left sternal border due to relative tricuspid stenosis was detected in 15 out of 20 patients (75%) and correlated with the degree of the left to right shunt at the atrial level.

Mitral valve prolapse manifested by mid-systolic click or late systolic murmur, or both, is probably the most common cardiac anomaly associated with secundum atrial septal defect but is more obvious in adolesents and adults than in children either before or after closure of the atrial defect. In this series, mitral valve prolaps was not detected either before or after surgery.

The electrocardiogram shows an rsR' pattern in aVR and the right precordial leads in practically all cases of ASD 2° (Nadas and Fyler, 1972). In this series the mean QRS axis in the frontal plane ranged from +85 to +150; right axis deviation was found in 10 patients (50%). Right ventricular strain (indicating right ventricular

Table 1 : *Clinical findings and time of surgery of 20 ASD 2° patients*

No.	Name	Sex	Age	Body weight	Body height	Auscultation			Surgery	
				kg (P)	cm (P)	Syst	Spl	MDM	Tech.	Date
1	M	F	3 8/12	16 (50)	99 (50)	+	+	—	SC+VT	2/24/84
2	D	F	6 8/12	20 (50)	120 (50)	+	—	—	SC	5/18/84
3	P	F	11 1/12	24 (10)	140 (05)	+	+	+	SC	8/31/84
4	D	F	10 6/12	28 (25)	144 (50)	+	+	+	SC	9/03/84
5	F	F	13 2/12	38 (25)	145 (25)	+	+	+	SC	1/15/85
6	O	M	8 8/12	18.5 (05)	116 (05)	+	+	+	SC	2/04/85
7	A	F	6 5/12	15.5 (10)	107 (10)	+	+	+	SC	2/07/85
8	H	F	4 7/12	13.5 (05)	100 (05)	+	+	+	SC	4/28/85
9	F	M	9 6/12	20 (05)	120 (05)	+	+	—	SC	5/29/85
10	D	M	5 6/12	16 (10)	111 (25)	+	+	+	PP	12/09/85
11	F	M	13 2/12	29 (10)	142 (10)	+	+	+	SC	6/18/86
12	R	M	13 9/12	27 (05)	136 (05)	+	+	+	SC	12/19/86
13	N	F	8	18 (05)	118 (05)	+	+	+	SC	1/05/87
14	Y	M	6 7/12	16 (05)	105 (10)	+	+	+	SC	4/13/87
15	Y	F	8 11/12	23 (25)	125 (25)	+	+	+	SC	6/08/87
16	F	M	8 09/12	19 (05)	120 (05)	+	+	+	SC	9/16/87
17	N	M	8 2/12	18.5 (05)	120 (05)	+	+	+	SC	4/16/88
18	T	F	9 4/12	17 (05)	108 (05)	+	+	+	SC	6/20/88
19	I	F	5 4/12	21 (75)	114 (75)	+	+	+	SC	8/01/88
20	M	F	3 6/12	12 (10)	90 (10)	+	+	+	SC	11/14/88

Abbreviations :

Tech. : Technique of ASD closure
SC : Simple closure
PP : Pericardial patch
VT : Pulmonal valvulotomy
Syst : Ejection systolic murmur
Spl : Widely fixed split second heart sound
MDM : Mid diastolic tricuspid flow murmur
P : Percentile
M : Male
F : Female

Table 2 : *Age and sex distribution of 20 ASD 2° patients*

Age (yrs)	Male	Female	Total	%
3 —	0	3	3	15.0
5 —	2	3	5	25.0
7 —	3	2	5	25.0
9 —	1	2	3	15.0
11 —	2	2	4	20.0
Total	8	12	20	100.0

Table 3 : *Non-invasive and invasive laboratory findings of the 20 ASD 2° patients.*

No.	Sex	Age (yrs)	ECG					CXR		Echo		Cath		AA
			RAD	PR >	IRBBB	RAE	RVH	CTR >	PVM	PSM	ASD	FR	RR	
1	F	3 8/12	+	—	+	+	+	+	+	+	—	2.4	6.6	PS
2	F	6 8/12	—	—	+	+	+	+	+	+	—	2.1	8.3	
3	F	11 1/12	—	—	+	+	+	+	+	+	+	3.0	7.0	
4	F	10	—	—	+	+	+	+	+	+	+	3.0	3.1	
5	F	13 2/12	—	—	+	+	+	+	+	+	+	3.7	2.6	
6	M	8 8/12	+	—	+	—	+	+	+	+	+	2.5	16.0	
7	F	6 5/12	+	—	—	+	+	+	+	+	+	3.5	12.0	
8	F	4 7/12	—	+	+	+	+	+	+	+	+	2.7	7.0	
9	M	9 6/12	—	—	+	—	+	+	+	—	—	1.7	7.0	
10	M	5 6/12	+	+	+	+	+	+	+	+	—	2.5	8.0	
11	M	13 2/12	—	—	+	+	+	+	+	+	+	2.8	4.0	
12	M	13 9/12	—	—	+	+	+	+	+	+	+	3.3	3.2	VSD
13	F	8 9/12	—	—	+	—	+	+	+	+	+	2.8	8.5	
14	M	6 7/12	+	—	+	+	+	+	+	+	+	6.3	4.5	
15	F	8 11/12	+	+	+	+	+	+	+	+	+	2.5	9.0	
16	M	8 9/12	+	—	+	—	+	+	+	+	+	2.8	8.0	
17	M	8 2/12	+	—	+	+	+	+	+	+	+	—	—	
18	F	9 4/12	+	—	+	—	+	+	+	+	+	3.0	8.0	
19	F	5 4/12	+	—	+	+	+	+	+	+	—	2.5	6.0	
20	F	3 6/12	+	—	+	—	+	+	+	+	+	2.8	8.9	

Abbreviations :

ECG : Electrocardiogram
RAD : Right axis deviation
PR > : Prolonged PR-interval
IRBBB : Incomplete right bundle branch block
RAE : Right atrial enlargement
RVH : Right ventricular hypertrophy (volume overload)
ASD : Visualized ASD 2°
AA : Associated cardiac anomaly
CXR : Chest X-ray
CTR : Cardio-thoracic ratio
PVM : Pulmonary vascular markings
Echo : Echocardiogram
PSM : Paradoxical ventricular septal motion
FR : Flow ratio (Qp/Qs)
RR : Resistance ratio (Rp/Rs)
Cath : Cardiac catheterization
PS : Valvular pulmonal stenosis
VSD : Ventricular septal defect

pressure overload) was not seen in all cases. Incomplete right bundle branch block and right ventricular volume overload pattern were seen in all cases, while right atrial enlargement and prolonged PR-interval were detected in 65% and 15% of cases respectively (table 3 and 4). Nadas and Fyler (1972) had also noted prolonged PR-interval in 10 per cent of ASD 2° cases. There are two factors that contribute the prolongation of the PR-interval: (1) Any large atrial septal defect altered a large segment of the anatomy of the atrial septum that might affect the three specific atrial pathway which conducted faster than surrounding atrial muscle (Meredith and

Titus, 1968) and (2) the right atrial enlargement required to accomodate the hemodynamic volume overload increases the distance of the SA node and the AV node.

In this series, cardiothoracic ratio of greater than 0.50 with small aortic arch were seen in all cases, though Feldt et al. (1983) reported some patients with large left-to-right shunt who showed normal heart size on roentgenogram. Distinct enlargement of the main pulmonary artery and its major branches associated with increased pulmonary vascular markings were also demonstrated in all cases (tables 3 and 4).

Volume overload of the right side of the heart, secondary to left-to-right shunting at the atrial level, characterized by increased right atrial and right ventricular dimension and paradoxical ventricular septal motion were seen on M-mode echocardiogram in most caese (95%). Visualization of the atrial septal defect by two dimentional echocardiogram were found in 15 out of 20 patients (75%) (table 3 and 4). Utilizing multiple tranducer positions for direct visualization and contrast echocardiography for appreciation of right-to-left and left-to-right shunt, nearly all instances of ASD 2° can be confidently diagnosed by noninvasive echocardiography (Feldt et al., 1983). Recently, colour-code echocardiography could increase both sensitivity and specificity to nearly 100% in diagnosing ASD 2°.

Cardiac catheterization was performed in 19 patients (95%). The pulmonary-systemic flow ratio ranged from 1.7 to 6.3 (mean 2.9 ± 0.7) and the pulmonary-systemic resistance ratio ranged from 2.6 to 16.0 (mean 7.1 ± 2.5). Eighteen out of 19 patients showed high pulmonary-systemic flow ratio (Qp/Qs > 2.0), and 17 out of 19 patients had pulmonary-systemic resistant ratio of less than 10%. The flow ratio has a good correlation with the presence of mid diastolic tricuspid flow murmur. Generally, as was also noted in this series, the right ventricular pressure is not elevated, although peak systolic pressure gradient across a normal pulmonic valve of as high as 40 mmHg have been reported. Pulmonary arterial pressure is usually normal, as is the calculated pulmonary artery resistance (less than 4 units/m^2) (Feldt et al., 1983).

Table 4 : *Age distribution and laboratory findings*

Age (yrs)	ECG										CXR				Echo				Cath			
	RAD		PR		RAH		IRBBB		RVH		CTR		PVM		PSM		ASD		FR		PH	
	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	+	—	H	L	—	+
3 —	2	1	1	1	2	1	3	0	3	0	3	0	3	0	3	0	2	1	3	0	3	0
5 —	3	2	1	4	5	0	5	0	5	0	5	0	5	0	5	0	2	3	5	0	5	0
7 —	4	1	0	5	2	3	5	0	5	0	5	0	5	0	5	0	5	0	4	0	4	0
9 —	1	2	0	3	1	2	3	0	3	0	3	0	3	0	2	1	2	1	3	0	3	0
11 —	0	4	0	4	3	1	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0
Total	10	10	2	20	13	7	20	0	20	0	20	0	20	0	19	1	15	5	19	0	19	0

Table 5 : *Clinical and laboratory findings of 20 ASD 2° patients after surgery*

No.	Follow-up (yrs)	Sex	Age (yrs)	Body weight kg (P)	Body weight cm (P)	HM	ECG	CTR >	Echo
1	5	F	8 8/12	27.5 (50)	130 (50)	—	IRBBB	—	N
2	+								
3	4 5/12	F	15 6/12	39 (10)	153 (50)	—	IRBBB	—	N
4	4 5/12	F	14 11/12	45.5 (50)	150 (25)	—	IRBBB	—	N
5	4 1/12	F	17 3/12	38 (05)	145 (05)	—	IRBBB	—	N
6	1 3/12	M	9 11/12	20 (05)	120 (05)	—	IRBBB	—	N
7	6/12	F	6 11/12	18 (25)	111 (10)	—	IRBBB	—	N
8.	3/12	F	4 10/12	13.5 (05)	100 (05)	—	IRBBB	—	N
9	4/12	M	9 10/12	21 (05)	122 (05)	—	IRBBB	—	N
10	3 2/12	M	8 8/12	22,5 (10)	125 (25)	—	IRBBB	—	N
11	1/12	M	13 3/12	30 (10)	143 (10)	—	IRBBB	—	N
12	2 2/12	M	15 11/12	42 (10)	157 (10)	—	IRBBB	—	N
13	2 1/12	F	10 1/12	24.5 (10)	130 (05)	—	IRBBB	—	N
14	2	M	8 7/12	22.5 (10)	125 (25)	—	IRBBB	—	N
15	1 8/12	F	10 7/12	34 (50)	144 (50)	+	IRBBB	+	RV >
16	1 5/12	M	10 2/12	130 (05)	23.5 (10)	—	IRBBB	—	N
17	9/12	M	8 11/12	21 (10)	124 (05)	—	IRBBB	—	N
18	8/12	F	10	19 (10)	120 (05)	—	IRBBB	—	N
19	6/12	F	5 10/12	32 (90)	122 (90)	—	IRBBB	—	N
20	+								

Elective repair of ASD 2° is simple and safe. The usual approach is through a median sternotomy. Usually, closure can be accomplished by direct approximation of the edges of the defect, which was performed in 19 out of 20 patients (95%). In one patients, a pericardial patch was used to achieve closure of the very large defect. Complication of surgery in children should be rare, but unfortunately two patients died, one patient died on table of profuse bleeding and the other deceased 12 hours after surgery of respiratory failure. Thus the mortality rate was 10 per cent.

After surgery (table 5, 6 and 7), the body weight precentile increased in 11 out of 18 patients (61.1%) and the body height percentile increased in only 1 out of 18 patients (5.6%). The improvement of body weight percentile was not significantly greater in patients operated upon under 7 years of age. This finding was in contrast against the earlier studies in PDA patients (Suoninen, 1971; Madiyono et al., 1989) in which the best improvement was seen in children operated on generally at an earlier age.

A faint midsystolic ejection murmur,

Table 6 : *Change of body weight percentile after surgery based on age group*

Age group (yrs)	Change of body weight percentile		Total
	Increased	Unchanged	
7	4	2	6
7	7	5	12
Total	11	7	18

$p > 0.05$

Table 7 : *Change of body height percentile after surgery based on age group*

Age group (yrs)	Change of body height percentile		Total
	Increased	Unchanged	
7	2	4	6
7	1	11	12
Total	3	15	18

$p > 0.05$

probably related to dilation of the pulmonary artery, may be present in many patients after succesful repair of ASD 2°. The tricuspid diastolic murmur, if audible preoperatively, should disappear immediately after surgery. In this series soft ejection systolic murmur was still detected in one patient (5.6%).

The electrocardiogram may not return entirely to normal in patients after repair of an ASD 2°. The mean QRS frontal plane axis may shift to the balance axis zone from the usual preoperative rightward displacement. Failure of the R' deflection in the right precordial leads to decrease significantly suggested pulmonary hypertension. In this series although the RBBB was still present the R' deflection in the right precordial leads decreased significantly in all cases; in those with right axis deviation, the QRS shifted to normal axis in all cases. The right atrial enlargement evident preoperatively, disappeared after surgery in all cases; while right ventricular hypertrophy persisted in 5.5% of cases followed-up 6 months to 5 years after operation.

Persistent enlargement of the main pulmonary artery is usually seen even if the postoperative hemodynamic status is normal (Amplatz, 1975), though radiographic evidence of cardiomegaly after sucessful repair of ASD 2° in childhood has been unusual (McNamara and Latson, 1983). However, Young (1973) noted increased heart size in 20 per cent of his patients 5 to 13 years after operation. In our series one case had persistent cardiomegaly and enlargement of the main pulmonary artery followed-up 6 months to 5 years, after surgery.

Although regression of ventricular dilation has been shown to be incomplete in several studies of short follow-up of children, it is rare that an older children or even an adolescent shows clinical sign of right ventricular dysfunction after succesful closure of an atrial septal defect in childhood (Graham, 1983). Pearlman et al. (1978) found persistent abnormalities of right ventricular diastolic diameter on echocardiography in 77 per cent of patients studied 5 to 38 months after surgery. Thus there appear to be some patients with persistent right ventricular dysfunction despite adequate repair of an atrial septal defect. The persistent enlargement appeared to be due to failure of regression of the previously enlargement right ventricle and right atrium and thus was considered as cardiomyopathy of volume loading (McNamara and Latson, 1983). Fortunately, these patients are in the minority (Graham, 1983).

There have been reports of abnormal left heart function after operation for atrial septal defect. These abnormalities were thought to be in many instances either to acquired disease or to the decreased filling of an abnormally small left ventricle due to chronic underloading of this chamber in the presence of a large left to right shunt or to altered diastolic filling characteristic of the left ventricule in the presence of a large ventricule with the septum bowing posteriorly. Despite these factors are presented in adult with atrial septal defect, repair of atrial septal defect in childhood has not been associated with residual left ventricular dysfunction (Graham, 1983). In this series, there was no residual left ventricular dysfunction in all cases.

Conclusions

(1) ASD 2° affected girls more than boys, the sec ratio was 1.5 : 1.
(2) Typical clinical findings, incomplete right bundle branch block and cardiomegaly with increased vascular markings were found in all cases.
(3) Physical retardation, paradoxical ventricular septal motion, visualization of the ASD and left to right shunt with high flow and low resistance ratio were found in most cases.
(4) Simple closure of ASD 2° was the procedure of choice, with mortality rate of 10 per cent.
(5) Increased in body weight were observed in most cases, post operatively.
(6) Right and left ventricular dysfunction were not noted in most cases, postoperatively.

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