Effects of Corrective Surgery on Natural History of Atrial Septal Defect of Secundum Type

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Two hundred and seventy-eight patients with atrial septal defect of secundum type were operated on surgical closure of the defect. The patients were divided into 5 groups according to age at surgery, and preoperative complaints and laboratory findings were analyzed to evaluate natural history.

As year passed, incidence of complaints increased. Cardiopulmonary ratio (CTR), systolic pressure of the right ventricle (PRV), end-diastolic pressure of the right ventricle (RVEDP), mean pressure of the right atrium (PRA), ratio of pulmonary to systemic systolic pressure (Ppa/Ps), right ventricular dimension (RVD) and left atrial dimension (LAD) increased significantly, while frontal axis of the QRS complex, RV, SV1 +RV5 and LVD decreased. No chronological changes were seen in ratio of pulmonary to systemic blood flow (Qp/Qs) and ratio of pulmonary to systemic vascular resistance (Ppa/Psc). The first and second decades of life were considered to be stable stages of the disease.

Postoperatively, changes in the above-mentioned parameters were compared in each age group, and effects of surgical repair on natural history were evaluated. Of 265 survivors, 168 were followed-up for more than one year, the longest period being 22 years. CTR, frontal axis, RV, PRV, RVEDP, Ppa/Ps and RVD decreased significantly, while SV1 +RV5, Ppa/Psc and LVD increased. No changes were seen in LAD. Surgical effects appeared most significantly in the first decade and least in the fifth or more.

From these findings it would be concluded that corrective surgery should be best carried out in the first decade, at latest in the second, though not to be contraindicated by age alone. Otherwise, postoperative improvement of parameters delays or hemodynamical abnormalities may persist regardless of considerable clinical improvement.

Surgical closure of atrial septal defect of secundum type (ASD II) has become one of the standard procedures in the cardiac surgery for past three decades. Because of the low surgical risks, less attention seems to be paid to long-term results of the procedure. We have achieved a postoperative study in 63 patients up to 5 years and concluded that surgical closure of the defect, though had been considered for a long time to be a completed operation, still had some problems to be solved from the viewpoint of radicality of the disease.

It is the purpose of this communication to clarify effects of surgical repair carried out at

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various ages of life on natural history of the disease more extensively and in detail.

MATERIALS AND METHODS

During the period between 1957 and 1979, 278 patients were operated on primary or patch closure of ASD II, and were subjected to this study. Patients with additional abnormalities were excluded but with left superior vena cava attached to the right atrium. There were 101 males and 177 females, and the age at surgery averaged 20.8 ± 12.8 (mean ± SD) years, ranging from 2 to 54 (Fig. 1). The patients were divided into 5 groups according to the age, 68 patients being in the first decade of life, 79 in the second, 56 in the third, 47 in the fourth and 28 in the fifth or more.

Preoperatively, parameters from plain chest film, ECG, cardiac catheterization and UCG were averaged in each group, and compared to evaluate any aging effects on parameters from the standpoint of natural history.

There were 13 operative deaths. The vast majority of deaths occurred before 1965, and the operative mortality rate has been reduced down to 0.71% since then.

Postoperatively, patients were followed up regularly at the Outpatient Department (OPD) as long as possible, and laboratory examination was restricted to plain chest film and ECG; and UCG recently. In 66 patients, however, cardiac catheterization was repeated in the third or fourth postoperative week, immediately before discharge from the hospital. The above-mentioned parameters were compared in each age group, and effects of surgical repair on natural history was evaluated. Among 265 survivors, 168 were followed up, 111 at OPD and 57 by a questionnaire, over one year after surgery, the longest follow-up period being 22 years. Ninety-seven patients lost to follow-up due partly to excellence in clinical improvement after surgery (Fig. 2).

Fig.3. Complaints, preoperative.

RESULTS

1. Preoperative studies

1) Complaints

Major complaints were easy fatigability, and exertional palpitation and shortness of breath. Less frequently, chest pain and arrhythmias were encountered. The number of patients with such complaints gradually increased from 26% in the first decade to 93% in the fifth or more (Fig. 3). There were statistically significant differences between the first and second (p < 0.05), and the second and third decades (p < 0.001).

2) Cardiothoracic ratio (CTR)

CTR in the first decade was 54.9 ± 5.0%. The value increased from 53.6 ± 5.3% in the second decade to 60.0 ± 4.7% in the fifth or more decade. There was a statistically significant difference between values in the second and fourth decades (p < 0.01) (Fig. 4).

4) ECG findings

Frontal axis of the QRS complex decreased from 96 ± 21 degrees in the first decade to 88 ± 22 degrees in the fifth or more decade. In each decade, the values shifted more to the right than those from normal individuals.

The amplitude of R or R' in the lead V1 (RV1) decreased gradually from 1.07 ± 0.54 mV to 0.78 ± 0.49 mV with age. There was a significant difference between values in the first and fourth decades (p < 0.01).

The value of SV1 + RV5 showed a similar tendency, and decreased from 2.09 ± 0.76 mV to 1.71 ± 0.59 mV. There was a significant difference between values in the first and fifth or more decades (p < 0.02) (Fig. 5).

4) Hemodynamical findings

Systolic pressure of the right ventricle (PRV5) elevated moderately to show between 44 ± 15 mmHg in the third decade and 50 ± 20 mmHg in the fourth decade. There were no significant differences between values in each age group.

End-diastolic pressure of the right ventricle
(RVEDP) revealed 6.5 ± 3.9 mmHg in the first decade. The value in the second decade showed 6.0 ± 3.0 mmHg, and increased gradually with age to 8.5 ± 3.5 mmHg in the fifth or more decade. There was a significant difference between values in the second and fourth decades (p < 0.02).

Mean pressure of the right atrium (P_{RAM}) showed a similar tendency (Fig. 6). There was a significant difference between the values in the second and fourth decades (p < 0.01).

The ratio of pulmonary to systemic blood flow (Q_{PA}/Q_{S}) showed between 2.6 ± 1.1 in the first decade and 3.1 ± 1.4 in the fourth decade. The ratio may increase with age up to the fourth decade, and decrease thereafter. No significant differences, however, were detected.

The ratio of pulmonary to systemic systolic pressure (P_{PA}/P_{S}) staid below 0.28 before the fourth decade, and exceeded 0.34 thereafter (p < 0.01). As a whole, severe pulmonary hypertension (P_{PA}/P_{S} > 0.7) was encountered only in 7 patients (3%).

The ratio of pulmonary to systemic vascular
resistance ($R_{PA}/R_S$) decreased with age from $0.078 \pm 0.059$ in the first decade to $0.055 \pm 0.044$ in the third decade, and exceeded 0.08 thereafter (Fig. 7). There was a significant difference between values in the third and fourth decades ($p < 0.05$).

5) UCG findings

Left ventricular dimension (LVD) decreased somehow showing approximately 80% of the normal in all age groups. Right ventricular dimension (RVD) increased markedly, approximately 2.5 times as large as the normal in the age less than 20 years, and 2 times over 20 years. The ratio of LVD to RVD showed between 1.08 and 1.26, and revealed approximately 40% of the normal in all age groups. Left atrial dimension (LAD) was within normal limits in the age less than 20 years. Thereafter, the value increased gradually with age to reach approximately 140% of the normal in the fifth or more decade (Fig. 8). There was a significant difference between values in the third and fifth or more decades.

2. Postoperative studies

1) Hemodynamical findings

$P_{RVS}$ and RVDP decreased to the normal or near normal level. Significant differences in the decrease were noted in the first, third and fourth decades in the former, and in the first and fourth decades in the latter. $R_{PA}/R_S$ decreased also with significant differences in the first and fourth decades. Postoperative values, however, staid higher than the normal especially in patients over 30 years of age. $R_{PA}/R_S$ increased significantly but in the second decade, and all postoperative
values were within normal limits (Fig. 9). None of patients showed any residual shunt detected.

2) UCG findings

LVD increased significantly in all age groups. In patients below 20 years of age, postoperative values indicated within normal limits, and those from patients over 20 years showed approximately 87% of the normal. RVD decreased significantly in the second, third and fourth decades, and postoperative values indicated approximately 150% of the normal. The ratio of LVD to RVD increased except in the fifth or more decade. No significant changes were seen in LAD (Fig. 10).

3) CTR

CTR decreased significantly except in patients in the fourth decade. Postoperative values indicated less than 50% in patients younger than 20 years. However, the value showed 55.3 ± 5.4% in the fifth or more decade, and a significant difference was detected with that in the first or third decade (P < 0.01) (Fig. 11).

4) ECG findings

Frontal axis of the QRS complex decreased significantly in all age groups. The tendency of a rightward shift comparing with normal individuals, which had been noted preoperatively, remained postoperatively, values being between 70 and 80 degrees in patients younger than 30 years and between 50 and 60 degrees in patients older than that. RV₁ decreased significantly in the first, second and third decades. SV₁ + RV₅ increased significantly in the first, fourth and fifth or more decades. The tendency of decrease in values with age remained postoperatively.
5) CTR and ECG findings more than 5 years after surgery

Though aging effects may appear on various parameters in addition to effects of surgical closure of ASD II per se, CTR and ECG findings were figured more than 5 years after surgery.

In 54% of patients enabled to be followed up longer than 5 years, CTR showed below 50%. However, in some patients, especially older than 20 years at surgery, cardiomegaly remained. In 70% of patients, frontal axis of the QRS complex showed between 50 and 80 degrees, and a few revealed right axis deviation. In 85% of patients, R_{V1} was less than 0.5 mV, and a few younger patients had a high amplitude. In 63% of patients, S_{V1} + R_{V5} ranged from 1.8 to 3.5 mV. A high value was seen in a few younger patients, while a low value was seen in a few older patients (Fig. 13).

DISCUSSION

1. Natural history

In uncomplicated ASD II, death rarely occurs in infancy and childhood, the heart is not particularly handicapped as a rule, the pressure in the right ventricle and pulmonary artery is only slightly elevated, and the life expectancy may, on the average, be around 50 years, although an
occasional case may live to be 80.\textsuperscript{2} However, after the childhood as the time passes, various potential causes of death begin to appear leading to congestive heart failure, hyperkinetic pulmonary hypertension, and atrial fibrillation.\textsuperscript{4} A few may die of obstructive pulmonary vascular disease.\textsuperscript{5} Infection may add its effects to any of these.

Because of corrective surgery being carried out with low risks in childhood, studies on natural history of the disease can no longer be easily organized, and repetition of cardiac catheterization on unoperated patients during a long period of time, as have been reported by some investigators,\textsuperscript{6,7} may become exceptional at the present time. Therefore, comparison of preoperative parameters obtained from surgical patients and arranged according to the age should add further reasonable interpretations to natural course of the disease. Thus obtained data are summarized in Fig. 14. As the time passed, $Q_{PA}/Q_S$ and $P_{RV_S}$ tended to increase, while LAD staid within normal limits and CTR, frontal axis, $R_{V_1}$ and $S_{V_1} + R_{V_S}$ decreased somehow in patients in the second decade. From the standpoint of natural history of ASD II, therefore, the second decade of life may be considered to be a stable stage of the disease. After 20 years of age, abnormalities of various parameters became manifest and began to shift with age towards those of the fifth or more decade. Increase in CTR, RVEDP and LAD, and decrease in $R_{V_1}$ and $S_{V_1} + R_{V_S}$ were distinct. These findings were compatible with significant increase of complaints in patients older than 20 years.

2. Surgical intervention

In 1971, Moss and Siassi\textsuperscript{8} summarized the current opinion among pediatric cardiologists regarding surgical closure of ASD II, in the asymptomatic child. There was almost complete unanimity when $Q_{PA}/Q_S$ was 2.0 or greater. Approximately 30% had some reservation when the ratio was between 1.5 and 2.0. In our series 74% of patients in the first decade had no complaints with $Q_{PA}/Q_S$ of $2.6 \pm 1.1$, while only 7% of patients in the fifth or more decade were free

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from symptoms with the ratio of $2.8 \pm 1.0$. In the vast majority of our patients, surgical correction diminished their complaints.

Many authors reported surgical correction of ASD II in adults, and some of them were concerned with patients over 60 years of age. Regardless of preoperative complications, such as pulmonary hypertension, atrial fibrillation and congestive heart failure, repair of ASD II with left-to-right shunt in adults produced considerable clinical and hemodynamical improvement and had low mortality and morbidity rates.

Kakihara carried out a postoperative study in 37 patients older than 30 years, and concluded that cardiac dysfunction, particularly of left ventricle, existed for a long time postoperatively in spite of good clinical results.

Mody confirmed spontaneous closure of ASD II in 11 patients out of 20 by means of cardiac catheterization repeated 1.5 to 14 years later. The closure, however, occurred in the patients younger than 1 year exclusively. Keith experienced spontaneous closure in 3% of his cases, and recommended surgical correction to be postponed until 4 or 5 years of age.

Results of surgical intervention in each age group are summarized in Table I. Surgical effects appeared most significantly in the first decade and least in the fifth or more. Less significance in the second decade may indicate a low grade of

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Fig.13. CTR and ECG findings more than 5 years after surgery.
Fig. 14. Summary of preoperative parameters in the first, second and fifth or more decades of life.

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*: P < 0.05,  **: P < 0.01,  ***: P < 0.001, NS: not significant

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abnormalities in preoperative parameters in this age group.

From these findings it would be concluded that corrective surgery of ASD II should be best carried out in the first decade of life. It may be carried out in the second decade, where the hemodynamical conditions are still stable from the standpoint of natural history. Thereafter, however, preoperative complaints and abnormalities in parameters increase significantly, and postoperative improvement of parameters may delay or hemodynamical abnormalities may persist after surgery.

REFERENCES