

Electrophysiological Abnormalities Before and After Surgery for Atrial  
Septal Defect

(心房中隔欠損症の術前後における電気生理学的異常)

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electrophysiological abnormalities of ASD

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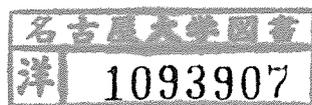
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## Abstract

We evaluated the electrophysiological parameters, atrial-His interval (AH), His-ventricular interval (HV), Wenckebach cycle length (WCL), corrected sinus node recovery time (CSNRT), and sino-atrial conduction time (SACT), before and after operation in 28 children with atrial septal defect (ASD). Before operation, electrophysiological abnormalities were detected in 20 (79%) of the 28 patients. Pre-operative comparison of the mean value in each parameter between two age groups showed higher values in all parameters in the older group. In 17 patients who underwent operation, AH, WCL, CSNRT, and AERP significantly decreased after operation; preoperatively abnormal WCL, CSNRT, and AERP values were normalized in many of them.

Thus, electrophysiological abnormalities were already present before operation in the ASD children and were severer in older children, but they were improved to some degree following operation.

Key words: atrial septal defect, conduction system, arrhythmia, electrophysiological study

## Introduction

Supraventricular arrhythmias such as atrial fibrillation and sick sinus syndrome are sometimes observed after operation for atrial septal defect (ASD),<sup>1-7</sup> and they have been attributed to surgical insult to the conduction system.<sup>3-7</sup> However, recent electrophysiological (EP) studies before and after operation for ASD have suggested the involvement of ASD itself in dysfunction of the conduction system.<sup>10-16</sup> We performed EP studies in 28 children with ASD and evaluated preoperative abnormalities, the effects of age, and changes after operation.

## Subjects and Methods

Of 35 patients with ASD who underwent preoperative cardiac catheterization at the Meijo Hospital between May, 1984 and October, 1986, 28 (10 males and 18 females) were entered into this study. Their age ranged from 2 to 16 years (mean, 9.2 years). We adequately explained to these patients and their parents the purpose (purely investigative nature) and content of this EP study and obtained their informed consent to perform the study before and after operation. Twenty six patients had ostium secundum defect, and the other 2 had sinus venous defect. As complications, mild pulmonary valve stenosis and patent left superior vena cava were observed in 1 patient each.

Of the 28 patients, 21 underwent operation during this study. A postoperative EP study was not performed in 2 patients due to slight postoperative impairment of liver function, and in 2 others because of refusal by their parents. The remaining 17 (mean age, 9.1) also underwent an EP study after operation. The interval between the preoperative EP study and operation varied from 8 to 349 days (mean, 92 days), and that between operation and the postoperative EP study from 17 to 184 days (mean, 41 days).

EP studies were performed under local anesthesia in 6 older children and under general anesthesia in the others using the same anesthetic method before and after operation in each child. All catheters were inserted via the femoral vein. A bipolar catheter was placed at the high right atrium for pacing and a tripolar catheter at the tricuspid orifice for recording of His bundle electrograms. His bundle electrograms were recorded by a modified method of Scherlag et al.,<sup>8</sup> and basal cycle length (BCL), atrial-His interval (AH), and His-ventricular interval (HV) were measured. Corrected sinus node recovery time (CSNRT), sino-atrial conduction time (SACT), Wenckebach cycle length

(WCL), which is the maximum atrial pacing cycle length that does not induce Wenckebach type grade 2 atrioventricular block, and atrial effective refractory period (AERP) were measured by programmed pacing and premature stimulation (stimulation width, 1.0 ms; voltage, 3.5 V). SACT was obtained by Strauss's method<sup>9</sup> and expressed as the total SACT. When 1 : 1 conduction was observed even at a pacing rate of less than 300 msec, further measurements were not performed in some patients, and the maximum pacing cycle length used was substituted for WCL.

## Results

### Preoperative abnormalities:

The mean value  $\pm$  SD in each parameter in the 28 patients preoperatively examined is shown in Table 1 and the detection rate of abnormal values in Table 2. Values that were more than twice the standard deviation of the previously reported normal values<sup>17-20</sup> were regarded as abnormal. EP abnormalities were present before operation in 22 (79%) of the 28 patients (Table 2). WCL, SACT, and CSNRT were abnormal in more than 50% each; all of AH, HV, WCL, SACT, CSNRT, and AERP were abnormal in some patients (Table 2).

The EP parameters were classified into those at the sinus node (SN), right atrium (RA) and the atrioventricular node (AVN), and the detection rates of abnormal values were compared among these sites. The detection rate of abnormal values was the highest at SN followed in order by AVN and RA.

The correlation coefficient between the systemic pulmonary flow ratio (Qp/Qs) and each parameter was calculated, but no significant correlation was observed.

### Effects of age:

The 28 patients preoperatively examined were classified into the

younger group aged 2 - 9 years (n= 14) and the older group aged 10 - 16 years (n= 14). The mean values  $\pm$  SD and the rates of abnormal values in each parameter were compared between these groups (Tables 2 and 3, respectively). The older group showed higher mean values (non-paired t-test) and detection rates of abnormal values in all parameters than the younger group.

Postoperative changes:

In 17 patients in whom both pre- and post-operative EP studies were performed, changes after operation were evaluated. Fig. 1 shows pre- and post-operative values in each parameter in the two age groups. AH, WCL, CSNRT, and AERP significantly decreased after operation ( $p < 0.05$ , paired t-test), but BCL, HV, and SACT did not differ between before and after operation. Preoperative abnormal values were normalized after operation in some patients; WCL was normalized in 3 of 8 patients, CSNRT in 5 of 9, and AERP in all of 5 (Fig. 1). Measurement of SACT was impossible because the plateau line could not be drawn in 7 of the 17 patients before operation but only in 2 after operation.

#### Discussion

Many EP studies have been performed in children,<sup>17-23</sup> mostly in those with congenital heart disease. On the other hand, AH and HV in normal children have been reported,<sup>17</sup> but not other parameters. Actual normal values might be lower than the values used in the present study. However, we considered that the detection rates of abnormalities are not at least overestimated using these normal values.

Reports have shown considerable high detection rates of preoperative EP abnormalities in ASD children,<sup>10-16</sup> which were supported by our results. Clark et al.<sup>10</sup> reported a correlation between EP abnormalities and Qp/Qs, but such correlation was not observed in the present study.

This may have been caused by the small deviation in Qp/Qs (2.1 - 2.6) in our subjects.

Rushhaupt et al.<sup>11</sup> observed preoperative EP abnormalities in 8 of 21 ASD children aged 2.5 years or more but none of 34 ASD children aged less than 2.5 years and suggested age as an important factor associated with preoperative EP abnormalities. In our study, significant differences were observed in all parameters between the older and younger groups, also strongly suggesting the effects of age. Shiku et al.<sup>12</sup> provided more accurate data on significant prolongation in PA, HV and PR intervals with age in ASD children using normal children as controls.

As the effects of anesthesia, the mean value in each item and detection rate of abnormal values were similar between 6 of 14 older children examined under local anesthesia and the other 8 examined under general anesthesia. These findings suggest no effects of anesthesia on EP evaluation.

Bolens et al.<sup>13</sup> reported significant postoperative decreases in the same parameters as ours in 18 ASD children (mean age, 10 years). Though similar results were obtained in our study, SACT and HV did not significantly decrease after operation. However, the number of patients, in whom measurement of SACT was impossible, markedly decreased after operation. Kugler et al.<sup>18</sup> considered that impossibility of SACT measurement represents entrance block into SN and decreased SN function. Based on their theory, SACT may also tend to improve after operation. Bagger et al.<sup>15</sup> found no changes in PA, AH, SACT, and AERP and prolongation in SNRT and HV in adult patients (mean age, 32 years). This suggests that postoperative improvement in EP abnormalities become difficult with age.

Thus, EP abnormalities were preoperatively present in the ASD children, aggravated with age, but improved to some extent by operation.

We speculated that these serial changes are associated with the presence and duration of the left to right shunt at the atrial level. Therefore, ASD repair at earlier ages may be useful for preventing EP abnormalities.

None of our subjects had arrhythmia. Further studies are needed on whether subclinical EP abnormalities are useful for predicting the occurrence of arrhythmia late after operation.

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Table 1 Electrophysiological parameters (mean  $\pm$  standard deviation) prior to ASD repair.

	MEAN	$\pm$	SD
BCL	662	$\pm$	131
AH	93	$\pm$	20
HV	43	$\pm$	6
WCL	424	$\pm$	135
SACT*	199	$\pm$	57
CSNRT	341	$\pm$	116
AERP	222	$\pm$	41

\* Only data on 21 patients in whom SACT could be obtained are shown.

[Legend] BCL = basal cycle length, AH = AH interval,  
HV = HV interval, WCL = Wenckebach cycle length,  
SACT = sinoatrial conduction time, CSNRT =  
corrected sinus node recovery time,  
AERP = atrial effective refractory period.

Table 2 Frequency of abnormal electrophysiological parameters prior to ASD repair.

	Younger children (n=14)	Older children (n=14)	All children (n=28)	Upper normal limit**
AH	1 ( 7%)	6 (43%)	7 (25%)	< 104 <sup>17</sup>
HV	0 ( 0%)	2 (17%)	2 ( 7%)	< 51 <sup>17</sup>
WCL	4 (29%)	12 (86%)	16 (57%)	< 375 <sup>19</sup>
SACT*	2 (17%)	9 (90%)	11 (52%)	< 200 <sup>18</sup>
CSNRT	5 (36%)	13 (93%)	18 (64%)	< 275 <sup>18</sup>
AERP	2 (14%)	6 (43%)	8 (29%)	< 245 <sup>20</sup>
More than 1 item	10 (71%)	13 (93%)	22 (79%)	

\* Only data on 12 younger children and 9 older children in whom SACT could be obtained are shown.

\*\* Upper limits reported by Levin<sup>17</sup>, Kugler<sup>18</sup>, Krongrad<sup>19</sup> and DuBrow<sup>20</sup> were used.

[Legend] AH = AH interval, HV = HV interval, WCL = Wenckebach cycle length, SACT = sinoatrial conduction time, CSNRT = corrected sinus node recovery time, AERP = atrial effective refractory period.

Table 3 Preoperative electrophysiological parameters (mean  $\pm$  standard deviation) in younger and older children.

	Younger children (n=14, 2-9y)	Older children (n=14, 10-16y)
BCL*	589 $\pm$ 93	735 $\pm$ 124
AH*	82 $\pm$ 14	103 $\pm$ 19
HV*	40 $\pm$ 4	46 $\pm$ 7
WCL*	347 $\pm$ 94	502 $\pm$ 127
SACT*,***	163 $\pm$ 34	247 $\pm$ 42
CSNRT*	277 $\pm$ 84	406 $\pm$ 110
AERP**	203 $\pm$ 31	241 $\pm$ 43

\* p < 0.01      \*\* p < 0.05 ( by non-paired T-test )

\*\*\* Only data on 12 younger children and 9 older children  
in whom SACT could be obtained are shown.

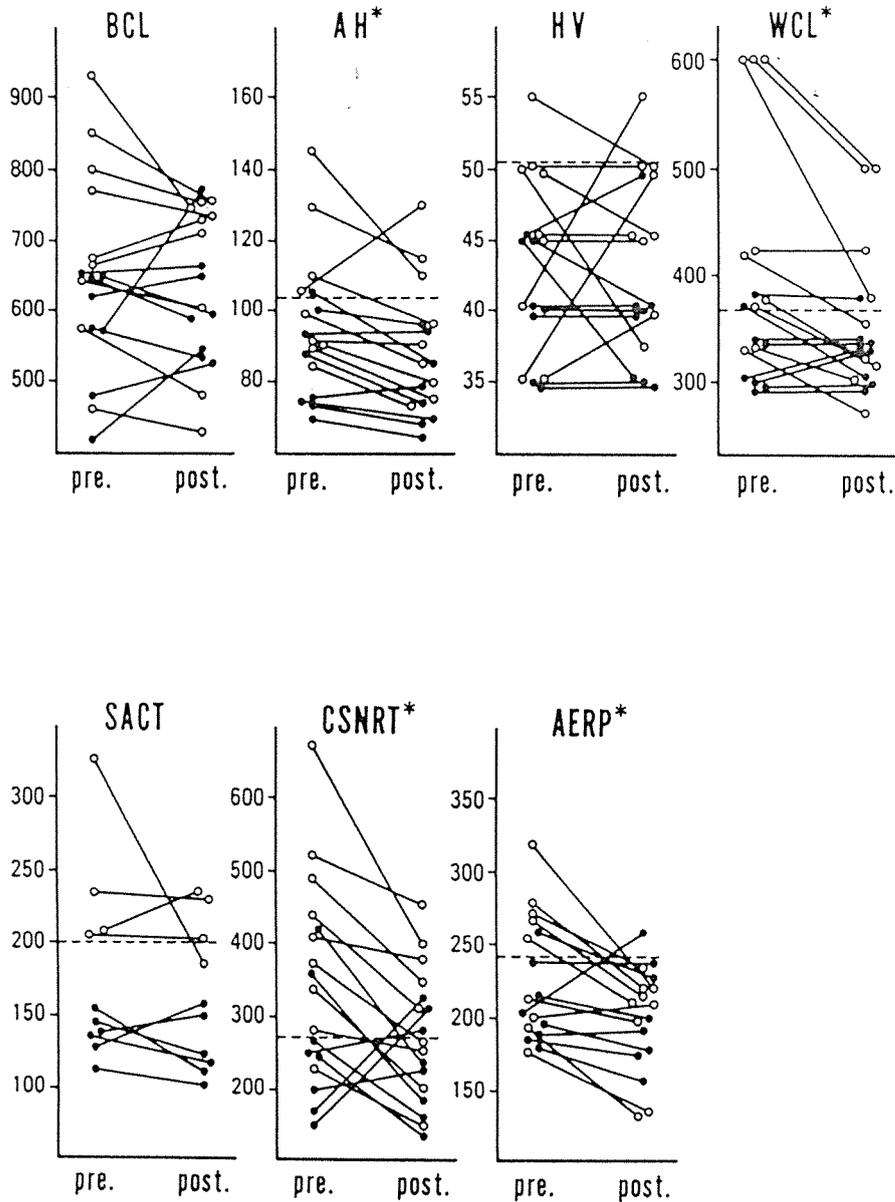
[Legend] BCL = basal cycle length, AH = AH interval, HV =  
HV interval, WCL = Wenckebach cycle length,  
SACT = sinoatrial conduction time, CSNRT = corrected  
sinus node recovery time, AERP = atrial effective  
refractory period.

Table 4 Frequency of abnormal electrophysiological parameters prior to ASD repair.

	Number of abnormal patients	Abnormal rate
SN	18	( 64 % )
RA	8	( 29 % )
AVN	16	( 57 % )

[Legend] SN = sinus node, RA = right atrium,  
AVN = atrioventricular node.

Figure 1 Postoperative changes in electrophysiological parameters.



\* Significant by paired T-test. (  $p < 0.05$  )

The broken lines indicate normal upper limits.

[Legend] BCL = basal cycle length, AH = AH interval, HV = HV interval,  
 WCL = Wenckebach cycle length, SACT = sinoatrial conduction  
 time, CSNRT = corrected sinus node recovery time,  
 AERP = atrial effective refractory period.