Surgery of Supraventricular Tachycardia

I. Operative treatment of Wolff-Parkinson-White syndrome

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SINCE 1969 when I performed the first successful surgery in Japan on the Wolff-Parkinson-White (W-P-W) syndrome¹, 19 patients with various types of the syndrome have been operated upon. The operation is now accepted as radical corrective surgery for this disease².

By interruption of the accessory conduction pathways in the W-P-W syndrome, all anomalies in ECG such as shortening of PQ interval, delta wave and QRS elongation as well as tachycardia attack disappear. This fact clearly indicates that the accessory conduction pathway is the essential cause of this disease.

CASE MATERIALS

To the present 19 cases of various type of the W-P-W syndrome have been operated on. Ages range between 2 years and 51 years, averaging 23 years. Twelve cases were less than 20 years, 3 cases between the ages of 21 and 40 years, and 4 were over the age of 40 years. They included 9 males and 10 females.

The eight cases operated upon between 1969–1972 at the Sapporo Medical College reveal a striking contrast to the 11 cases between 1973–1977 at the Kanazawa University with regard to the indication and results of surgery. In the former period the surgery was indicated for the patients who visited the outpatient department because of tachycardia attack.

In the later period all cases except one, who lived in Kanazawa city, were referred to us by cardiologists from all over Japan. The cardiologists diagnosed and treated the patients' tachycardias by means of conventional drug therapy which included digitalis, quinidine, procainamide, Ajmalin, β -blocker and so on. In many ordinary cases, drug therapy worked satisfactorily, but in some cases aggravation of the syndrome with

passage of time, increased frequency of the attacks and difficulty of drug therapy, became obvious and these patients were sent to us for surgery.

All these operated cases had frequent tachycardia attacks even with drug therapy, were controlled only with a large amount of drugs or DC counter shock, had congestive cardiac failure, and were combined with syncope or shock. Because of these factors 10 cases were life-threatening, 8 cases showed a hindrance to usual life, and one case had occasional mild tachycardia but corrected simultaneously when her ASD was closed.

CLASSIFICATION

The W-P-W syndrome could be classified according to electrocardiograms, epi- and endocardial mapping study or recognition of accessory pathway during surgery. Depending upon the localization of the accessory conduction pathway, it can be classified in 3 types; left cardiac, right cardiac and septal types. It was confirmed that the earliest excitation area of the ventricle corresponds very well to the localization of the pathway, which was recognized by the immediate change of ECG when interrupted. The localization of the pathway was confirmed in all 12 cases by both mapping and interrupting surgery (Fig. 1) and in 4 other cases by mapping only. The cases may be divided in type A and B according to Rosenbaum's³ classification of ECG, and further type C according to Ueda⁴. Type C is characterized showing a negative delta wave and complete negative QRS as well in V_1 . Type A (3 cases) corresponded to the left cardiac type, type B (6 cases) to the right cardiac and type C (3 cases) to the septal type. However, the pathways scattered all around the annulus and the

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ECG alone did not indicate the exact localization of the pathways, although the gross location such as right, left or septal could be easily assumed from a glance over the ECG.

Multiple accessory pathways were proved in 4 cases. They presented a difficult problem for surgery.

OPERATION

Location of the accessory pathways became obvious grossly by the above mentioned examination before operation, an anterior median sternotomy incision was made for the right cardiac type and a left antero-lateral incision for the left cardiac type⁵ The median incision was utilized for the septal type, multiple pathways, small left atrium of left cardiac type and children. In this approach the epicardial potential of the posterior surface of heart was difficult to examine.

The pericardium was opened and the electrical potential of the epicardium was taken from as many places as possible. The earliest excitation area of the ventricle could be easily determined. Counting of the time difference and making of the epicardial mapping is now computerized to save time.

Ordinal extracorporeal circulation method was utilized in cases of median sternotomy. In the left antero-lateral thoracotomy, the femoral artery and vein was cannulated and later the

right ventricle was cannulated through the pulmonary artery retrogradely.

Under complete heart-lung bypass the right atrium was widely opened lateral and parallel to the crista terminalis and the tricuspid annulus was exposed in the right or septal types (Fig. 2). Usually the operations proceeded while the heart was beating. Then the right atrium was detached from the tricuspid annulus by incision of 3–4 cm in length at the counterside portion of the earliest excitation area of the right ventricle. The coronary arteries and veins are embedded in the fat pad. The annulus was incised until this fat pad appeared. When the accessory pathway was interrupted, the electrocardiogram changed to normal immediately. The ECG should show no delta wave, tight QRS and change of electrical cardiac axis. The annulus was further incised approximately 3 cm in length in both directions so as to ensure the interruption of the multiple pathways, which may exist near by.

When the septal type was being dealt with, the A–V node and the His bundle were carefully avoided from the incision of the septal annulus. Electrical potential of this conduction was studied by means of bipolar electrode.

After the complete interruption of the accessory pathways the right atrium and ventricle were electrically stimulated several times to provoke the tachycardia of any other remaining

Location of Accessory Conduction Pathway

Fig.1. Location of accessory conduction pathway.

Fig.2.

pathway. Then the interrupted annulus was reapproximated with continuous suture of 4-0 Tevdek. Bleeding from this area with the pump off is very troublesome. The reapproximation of the annulus should be very careful. Occasionally meticulous mattress sutures with pledget were added.

In cases of left thoracotomy for the left cardiac type, a large incision was made from the left appendage to the inferior pulmonary vein to expose the mitral annulus (Fig. 3). Then the left atrium and ventricle were detached at the mitral

annulus in the same way of the right heart. When the heart was beating, a large tube was inserted into the left ventricle through the mitral orifice to avoid air embolization. Any part of the mitral annulus except the fibrous trigonum could be interrupted depending upon the place of the earliest excitation area of the left ventricle. The reapproximation of the annulus was just the same to the right.

RESULTS

Nineteen cases have been operated upon. As previously mentioned it would be appropriate to divide them in two groups. The results are shown in Table I, II. Increase of knowledge of this disease and improvement of surgical technique made possible a high rate of success in the later group. The former group consists of 8 cases. They have been reported on elsewhere in detail⁶

In the later period, 1973-1977, all surgery was performed at the Kanazawa University Hospital. Nine out of 11 were completely cured, which means normalized electrocardiogram without delta wave and no tachycardia attack. In 2 of the other cases, the delta wave disappeared once during the operation but appeared one to two weeks after the surgery. Those ECGs are different compared with those of pre-operation. This fact indicates the existence of multiple path-

Fig.3.

TABLE I SURGERY OF W-P-W SYNDROME

Result	No. of Pt.
Complete correction	12
ECG change, no tachycardia	4
ECG minimum change, tachycardia↓	1
Failure	2*
Total	19

* 1: Elective A-V block,
1: Radiofrequency PM

TABLE II SURGICAL RESULTS

Type	No. of Pt.	Success
Right	10	6
Septal	3	3
Left	6	3
Total	19	12

TABLE III SURGICAL RESULTS IN JAPAN

	Our Group		Others	Total
	1969-1972	1973-1977		
No. of patient	8	11	43	62
Disappearance of Delta Wave	3 (38%)	9 (82%)	18 (41%)	30 (48%)

ways. Among these 2 incompletely corrected cases, one case showed no tachycardia attack at all, while one other case still had tachycardia attacks, but much less frequency and intensity. Nine cases completely cured included 3 left cardiac type, 3 right cardiac type and 3 septal type. Among them a baby of 10 kg of body weight and another case of Ebstein's anomaly who had multiple pathways and tricuspid valve replacement at the same time, were included. The last case was particularly interesting. The case had two pathways, one in the posterior septum and another in the anterior septum. The posterior pathway worked only antegradely and the anterior one passed the impulse only retrogradely from the ventricle to the atrium. All these phenomena were satisfactorily studied during the surgery and both pathways were successfully interrupted.

A survey was made as to the results of surgery on the W-P-W syndrome in all Japan by means of questionnaire (Table III). Up to the end of 1976, 43 cases of W-P-W syndrome were operated upon in all Japan excluding our 19 cases reported here. Eighteen cases or 41.8% were completely corrected, fourteen cases or 32.5% resulted in only tentative or minimum change in the ECG. As far as the tachycardia attack is concerned, 21 cases showed no tachycardia attack, 16 cases decreased in intensity and/or frequency of the attack and 6 case failed.

DISCUSSION

There is no doubt now that the W-P-W syndrome occurs due to accessory conduction pathway(s), because such evidence was proved by surgical correction. At present three structures such as Kent bundle, James bundle and Mahaim fiber are cited as the accessory conduction pathways. All 19 cases operated upon by us showed a typical electrocardiography pattern such as delta wave, short PQ and wide QRS. The theoretical possibility of producing such ECG is that it is caused by the Kent bundle or combination of James bundle and Mahaim fiber.^{7,8} The sites incised in 12 completely corrected cases are various locations of annulus of both A-V valves. They are not the locations of James bundle or Mahaim fiber ever reported in the literature.^{9,10} As I mentioned in a previous communication,⁵ Kent bundle originally reported is obviously different from that which we are discussing at present. It is proper, therefore, to use the term of "accessory conduction pathway" rather than the Kent bundle, James bundle or Mahaim fiber.

The W-P-W syndrome used to be grouped in type A and B based on the electrocardiographic classification of Rosenbaum.³ Ueda⁴ further divided the type B in type B and C. From the surgical standpoint of view, the classification should indicate the site of the accessory conduc-

tion pathway clearly. It is mandatory for performing satisfactory surgery. We are classifying the W-P-W syndrome in three groups: left cardiac type, right cardiac type and septal type. Those having positive delta wave and upright main QRS in V_1 are the left cardiac type. Those having delta wave positive and downward main QRS in V_1 are the right cardiac type. The septal type shows that both delta wave and main QRS are negative in V_1 . The accessory pathway of the septal type corrected by the surgery existed in only the right side of the septum. A problem still exists, however, in cases of multiple pathways^{11,12}. Two cases even in the recent group, which had multiple pathways, showed only incomplete correction although their tachycardia attack did not reappear after the surgery.

Various electrophysiological studies other than the ECG such as vectorcardiography, atrial stimulation test, His bundle electrography, body surface potential and echocardiography have certain value and meaning. They give much information to make clear the physiology of the W-P-W syndrome.

Among those studies, direct measuring of the electrical potential of the epi- and endo-cardium, which was possible only at the time of surgery, indicated the precise location of the accessory pathway. It was mandatory for interrupting the pathway. It took, however, a painfully long time to make the epicardial map during surgery. We are applying a computerized method for study at present.

The epicardial mapping study may be simplified by measuring the earliest excitation area only at the respective A-V groove. Many figures obtained from our study^{1,5,6,13} and Duke's group¹⁴ as well, are almost the same and theoretically reasonable.

We have taken the electrical potential directly from the accessory conduction⁶. It was a sharp and fine deflection taken from the very limited atrial endocardium of the counterside of the earliest excitation of the ventricle. It was presumed that the electrical potential is that of the accessory pathway. The potential was taken only at the very limited area and from only two cases so far.

Indication of the surgery was not difficult to decide. Because all the cases except one were sent to us from many cardiologists from all over Japan, who treated their patients with drugs first and found in certain cases; (1) aggravation of the symptoms of tachycardia, (2) increasing frequ-

ency of tachycardia attack, (3) difficulty of drug treatment, (4) ventricular tachycardia or syncope which threatened the patients' lives. Frequency of sudden death in W-P-W syndrome is difficult to ascertain. It is presumed, however, that there must be quite a number of such patients from clinical experiences. Those cases who have atrial fibrillation, flutter or very short refractory period of the accessory conduction, have a tendency to produce ventricular tachycardia or fibrillation. Surgery is also indicated in such cases.

On the other hand, the safety of the surgery is now well demonstrated by this series. That is the recent 9 cases have been completely corrected in succession even including cases involving multiple pathways or a small baby. Therefore, the indication of surgery should be further extended. Sealey¹⁵ once stated that the difficulty and safety of operation of the W-P-W syndrome is now comparable to the closure of septal defect.

Combined cardiac diseases were frequently seen (Table I). Particularly the Ebstein's anomaly, which was seen in 3 out of 19 cases, has specific problems. All these 3 cases were either right cardiac or septal type, and no left cardiac type were found. Two out of these 3 cases were proved to have multiple pathways but corrected by the surgery, one of which even received tricuspid valve replacement at the same time. Another case in the beginning of this series was not corrected by the surgery but the atrial pacemaker is working satisfactorily at present. On the contrary point of view Ebstein's anomaly is associated with the W-P-W syndrome more frequently. The cause of death of the Ebstein's anomaly is often tachycardia and subsequent ventricular fibrillation. Therefore, tachycardia attack of the W-P-W syndrome combined with the Ebstein's anomaly should be operated upon at the same time.

When the corrective surgery is not successful, implantation of the radiofrequency atrial pacemaker^{16,17} or interruption of the His bundle⁶ had been performed. Since all recent cases have been radically corrected in succession it is believed that the safety of the surgery is now established and the above mentioned adjuvant therapy will be less needed.

The accessory pathway(s) of the W-P-W syndrome is a fine structure, which has been reported in histological study. The fiber-like pathway runs from the atrium to ventricle. The annular ring is the easiest part to interrupt the atrium from the ventricle. In the beginning, Sealey¹⁸ has

proposed interruption of the annulus from the epicardial side, while we¹ proposed incision from the endocardial side. It soon became obvious that only the endocardial approach makes the complete interruption possible avoiding damage to the thick ventricular myocardium and large coronary vessels near by. Duke's group¹⁹ is now using the endocardial approach as the improved method. The interrupted annulus should be reapproximated tightly. We have fortunately not observed a single case of bleeding from the reapproximation area. Hemostasis, however, will be very difficult from this area after the pump is off. Judging from the world literature, it seems that Duke's and our groups are only ones, which have series with high success rates. Among these two groups, however, the surgical techniques used are quite different in many respects. We performed the surgery under beating heart, while Duke's group did so with arrested heart. The surgical procedure may be easier under the arrested heart, but recognition of changes of ECG which appears when the pathway is interrupted, is difficult. We used a left side approach for the left cardiac type, and anterior median approach for the right cardiac and septal types, while Duke's group used the anterior median approach for all cases. But the anterior approach makes the epicardial mapping of the posterior left ventricle difficult. We chose the anterior approach in cases of small left atrium, children or multiple pathways, because it gives better exposition.

CONCLUSION

1. Nineteen patients of the W-P-W syndrome have been operated upon. These cases were classified in 3 groups according to their electrocardiograms: 6 cases of left cardiac type, 10 cases of right cardiac type and 3 case of septal type.
2. Twelve cases out of 19 were completely corrected. Their electrocardiograms showed no delta wave, normal PQ distance and tight QRS. The tachycardia attack did not appear after surgery with 8 years being the longest. The recent 9 cases have been completely corrected in succession.
3. Among the remaining 7 cases mostly in the begining of the series, 3 cases showed different delta wave and ECG pattern, but tachycardia attacks did not reappeared at all. Two cases showed minimum changes in their ECG, but their tachycardia appears only rarely and the intensity of the attack has been much less severe. One case combined with Ebstein's anomaly still has

tachycardia attack, which is controlled satisfactorily with implanted radiofrequency atrial pacemaker. Another case which had been operated on twice previously because of rheumatic mitral stenosis, underwent attempted interruption of the pathway followed by His bundle division and was successful, but died 2 weeks later because of fulminant hepatitis.

4. Because of the high rate of success, the interruption of the accessory pathway should be accepted as a curative method and the indication of surgery should be extended.

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