ATRIAL COMPARTMENT SURGERY FOR CHRONIC ATRIAL FIBRILLATION ASSOCIATED WITH CONGENITAL HEART DEFECTS

In three adult patients, two with atrial septal defect and one with Ebstein's anomaly, chronic atrial fibrillation was documented for 13, 21, and 3 years, respectively. Atrial compartment surgery was performed for ablation of the atrial fibrillation concomitant with repair of the cardiac defects. The operation was performed with traditional cardiopulmonary bypass and crystalloid cardioplegia myocardial protection. A U-shaped incision was made in the right atrium: a longitudinal incision 1 cm lateral and parallel to the sulcus terminalis, extending along the borders of the atrial septum to 3 cm (upper margin) and 1 cm (lower margin) distant to the tricuspid annulus. Cryolesions of the atrial isthmus between the upper incision margin and the tricuspid valve annulus were created at -60°C for 180 seconds at a time. After the operation, all three patients had restored and maintained normal sinus rhythm during follow-up periods of 32, 16, and 3 months. Doppler echocardiography detected the recovery of atrial contractility in all three patients. Atrial compartment surgery is a simple and effective method for elimination of chronic atrial fibrillation associated with congenital heart defects. (*J THORAC CARDIOVASC SURG* 1996;111:231-7)

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Atrial fibrillation is a common arrhythmia complication in adults with atrial septal defect,¹⁻³ and the incidence increases as patients age.⁴⁻⁶ The arrhythmia also occurs occasionally in association with other congenital heart defects, such as Ebstein's anomaly.^{7,8} Recent studies have demonstrated that atrial fibrillation not only compromises the cardiac functions but imposes substantial risks of stroke and death.⁹⁻¹² Repair of the atrial septal defect, however, rarely stops chronic atrial fibrillation once it has persisted for longer than 1 year.³⁻⁶

Atrial compartment surgery based on Moe's multiple wavelet hypothesis¹³ is designed to eliminate the atrial fibrillation, restore sinus rhythm, and restore the atrial contractility. The procedure divides the atrium into several compartments to re-

duce the atrial mass. This reduction contributes to the elimination of the arrhythmia. This operation has been proved effective in eliminating the chronic atrial fibrillation associated with mitral valve disease.¹⁴ In this study, the same surgical procedure was performed on three patients with congenital heart defects to treat their chronic atrial fibrillation.

Method

Case presentations

CASE 1. Patient 1 was a 53-year-old farmer known to have had a heart murmur since childhood. For the previous 13 years, he had had exertional dyspnea and palpitation. Electrocardiography (ECG) and 24-hour Holter ECG recordings showed permanent atrial fibrillation and incomplete right bundle-branch block. Antiarrhythmic medications, including digoxin and quinidine, were not efficacious. The echocardiogram showed a large atrial septal defect, dilated right atrium and ventricle, and a moderate tricuspid valve regurgitation. Cardiac catheterization confirmed the septal defect and showed the ratio of pulmonary flow to systemic flow to be 3.8.

CASE 2. Patient 2 was a 64-year-old housewife who had had a history of persistent palpitation since her early 40s. ECG at that time showed atrial fibrillation and incomplete right bundle-branch block. For the previous 3 years, she had had exertional dyspnea, hepatomegaly, and lower leg edema. Echocardiography showed an atrial septal defect, dilated right atrium and ventricle, and severe tricuspid valve regurgitation. Cardiac catheterization confirmed the

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Fig. 1. Atrial compartment surgery in atrial septal defect (ASD). *Left upper panel* shows an incision made 1 cm lateral and parallel to the sulcus terminalis on the right atrium. *Right panel* shows the incision extended along the borders of the atrial septum to 3 cm (upper margin) and 1 cm distant from the tricuspid annulus. A cryolesion (*dotted strip*) is made to the atrial tissue between the upper incision margin and the tricuspid valve (TV) annulus. CS, Coronary sinus.

cardiac defects and revealed a moderate pulmonary hypertension; the ratio of pulmonary flow to systemic flow was 3.0.

CASE 3. Patient 3 was a 24-year-old female college student with a history of palpitations since she was 12 years old. For the previous 3 years, she had had exertional dyspnea, hemoptysis, and palpitation. ECG showed chronic atrial fibrillation with right ventricular hypertrophy. Echocardiography and cardiac catheterization revealed Ebstein's anomaly with severe tricuspid regurgitation and markedly dilated right atrium and right ventricle but showed no atrial septal defect.

Operative technique. The operation was performed through a median sternotomy. Cardiopulmonary bypass was instituted through cannulations of the aorta and both venae cavae. The body was cooled to 30° C. During myocardial ischemia, myocardial temperature was kept below 15° C with chilled crystalloid cardioplegia infusion and topical ice cooling. The compartment surgery was performed with a U-shaped incision on the right atrium: an incision was made 1 cm lateral and parallel to the sulcus terminalis and curved along upper and lower borders of the atrial septum to 3 cm (upper incision) and 1 cm (lower incision) distant from the tricuspid annulus. The sinoatrial node and its artery were carefully protected from injury. Cryolesions were created by

applying a Cryounit 142 (Spemby Medical Corp, Andover, United Kingdom) at -60° C for 180 seconds at a time were to the atrial tissues between the upper incision margin and the tricuspid annulus to complete the compartment operation (Fig. 1). The purpose of the cryosurgery was to simplify the operative procedures involving the atrioventricular groove. After the procedure, the atrium was electrically divided into two compartments: one comprised the right atrial free wall and the other comprised the left atrium and the atrial septum. Both atrial compartments were electrically connected by the atrial tissues between the lower incision wound and the tricuspid annulus.

Through the atriotomy, the atrial septal defect was closed and the tricuspid valve regurgitation was repaired. In the patient with Ebstein's anomaly, plication of the atrialized right ventricle and posterior tricuspid annuloplasty were performed according to the method described by Danielson and coworkers.¹⁵ After release of the aortic crossclamp, air was evacuated through the left ventricle and the aortic root. The right atriotomy was then closed with the Prolene sutures (Ethicon, Inc., Somerville, N.J.). The patient was gradually weaned from cardiopulmonary bypass after core temperature had warmed up properly. The cardiac crossclamp times were 23, 26 and 46 minutes, respectively. Mean pumping time was 100.7 ± 20.5 min-

Fig. 2. The ECGs in patient 2 before (A) and 18 months after (B) the atrial compartment operation.

utes. The atrial compartment surgery on average increased the cardiac ischemic time for 5 to 10 minutes.

Postoperative care was the same as after other heart operations. Twenty-four hour ECG monitoring was undertaken during the hospital stay. All patients were followed up regularly at the clinic. Detailed history, ECG, and periodic 24-hour ECG Holter recordings were taken to detect cardiac rhythms. Pulsed Doppler echocardiography was used to assess the synchronous atrial contraction according to methods reported elsewhere.¹⁴ In the two patients with atrial septal defect, cardiac electrophysiologic studies were performed 12 month after operation.

Results

Two patients had smooth recovery after operation. Patient 3 had a complication of chylothorax, which necessitated prolonged chest tube drainage for 1 week.

All patients resumed sinus rhythm immediately after operation. During the first few days, atrial premature contractions were frequently noted in two patients (1 and 2). One episode of junctional tachycardia occurred in patient 3 on the second postoperative day. This tachycardia was stopped

with digoxin and amiodarone. Follow-up periods were 32, 16, and 3 months, respectively. One episode of atrial fibrillation occurred in the patient 2 during the third month after operation. This arrhythmia was converted to sinus rhythm with quinidine. Atrial fibrillation did not recur, even after the medication was stopped (Fig. 2).

Doppler echocardiographic studies revealed that contractility of both atria recovered within the first month after operation (Fig. 3). The peak atrial filling velocity and peak atrial/early diastolic filling velocity ratio increased gradually as with time after operation (Table I).

In the electrophysiologic studies, atrial activations in the right atrial compartment were found to synchronously follow the sinus impulses. A premature atrial stimulation at the right atrial compartment advanced the atrial activations in the septal-left atrial compartment. Both phenomena demonstrated functioning atrial connection between the compartments (Fig. 4). One of the two patients studied (patient 2) was found to have abnormal sinus node function. The sinus node

A **B**

Fig. 3. Doppler echocardiograms 2 months after operation in patient 3. Transmitral (A) and transtricuspid (B) inflow velocity profiles show that peak filling velocities of the atria (A), corresponding to active atrial contractions, synchronously follow the peak early diastolic filling velocities (E).

recovery time was 2020 msec (normal <1600 msec), and the sinoatrial conduction time was 225 msec (normal 50 to 150 msec). Because this patient had a normal heart rate (65 beats/min) at rest and had no presyncopal symptoms, pacemaker implantation was not recommended.

Discussion

In a 7-year period (1984 to 1991) a total of 84 adult patients 30 years or older underwent surgical repair of simple atrial septal defect in our hospital. Nine had chronic atrial fibrillation before operation and retained the same rhythm after operation dur-

Fig. 4. Electrophysiologic recordings in the patient 12 months after operation. Atrial activations in the right atrial compartment (*RA[F]*) synchronously follow the sinus impulses. A premature atrial stimulation (*S*) delivered at the right atrial compartment advances the atrial activations in the septal-left atrial compartment and the subsequent ventricular contraction (*star*). *HRA*, High right atrial lead; *A*, atrial electrogram; *His*, His bundle lead; *H*, His bundle electrogram; *V* = ventricular electrogram; *CS(d)*, distal coronary sinus lead; *CS(p)*, proximal coronary sinus lead; *RV*, right ventricular lead.

Table I. Transmitral and transtricuspid inflow patterns after atrial compartment surgery

Patient	Time (mo)	Transmitral			Transtricuspid		
		<i>E</i> (cm/s)	<i>A</i> (cm/s)	Peak <i>A/E</i> ratio	<i>E</i> (cm/s)	<i>A</i> (cm/s)	Peak <i>A/E</i> ratio
1	<1	81	41	0.506	46	25	0.543
1	2	64	30	0.469	35	20	0.571
1	>6	70	47	0.671	55	42	0.763
2	<1	106	33	0.311	49	36	0.735
2	2	71	34	0.479	61	42	0.689
2	>6	100	75	0.750	65	50	0.769
3	<1	NA	NA	NA	NA	NA	NA
3	2	61	58	0.951	86	53	0.616
3	>6	NA	NA	NA	NA	NA	NA

E, Peak early diastolic filling velocity; *A*, peak atrial filling velocity; *NA*, not available.

ing a mean follow-up period of 6 years. One patient with atrial fibrillation died of cerebral embolism during the follow-up period. Similar results have been reported in several previous studies.³⁻⁶ The data suggest that most chronic atrial fibrillation associated with atrial septal defect persists despite proper repair of the cardiac defect. This warrants surgical correction of atrial fibrillation because serious adverse effects have been documented with this arrhythmia. Surgery for atrial fibrillation has to be

simple, however, and add no complications and mortality to those carried by surgery to repair the heart defects.

Atrial compartment surgery is designed to divide the atrium into several equal or nearly equal parts while preserving their electrical connections. As the atrial mass is reduced, the number of wavelets in each atrial compartment is also reduced; when it falls below the critical threshold for sustenance of atrial fibrillation, according to Allesie and associ-

ates' study,¹⁶ the arrhythmia will cease. Conversely, if the number persists above the critical threshold, the fibrillation will persist. According to the hypothesis of Allessie and associates,¹⁶ more atrial compartments provide a better chance of fibrillation elimination, but at the cost of lessened atrial synchrony and increased surgical risks from longer bypass time. In previous studies,^{17, 18} it was found that a narrow bridge of tissue, less than 1 cm wide, left connecting two pieces of cardiac tissues can conduct normal impulses but will prevent the extension of fibrillation from one area to the other. In our surgical method, a 1 cm atrial bridge is therefore preserved to maintain the connections between atrial compartments. In our study, atrial compartment surgery proved efficacious for eliminating atrial fibrillation in patients with atrial septal defect and a patient with Ebstein's anomaly. Most important, the procedure itself is simple to perform. The additional operation added less than 10 minutes to the myocardial ischemic time. Also, none of the 22 patients in our previous study had any complications after the atrial compartment operation.¹⁴

The maze operation has been reported for surgical ablation of atrial fibrillation in a patient with atrial septal defect.¹⁹ The original idea of the maze operation was to divide all possible areas for macroreentry, which is believed to be the main mechanism of atrial fibrillation.²⁰ This method has been proved effective both in conversion to sinus rhythm and in restoring atrial contractility.¹⁹ The maze operation is a meticulous and time-consuming operation, however, and it takes much more operative time than does an atrial compartment operation. Although no detailed Doppler data have been provided after the maze operation, atrial compartment surgery may preserve more atrial synchrony because fewer atrial segments are created.

Limitations. Some limitations of this study should be noted. First, the number of patients in this study is small, which could cause some bias in the results. Second, two-compartment operations seems efficacious for eliminating chronic atrial fibrillation associated with atrial septal defects and Ebstein's anomaly. Whether more atrial compartments would be necessary for other kinds of congenital heart defect was not determined in this study.

Summary. This study showed that atrial compartment surgery is a simple and effective method for eliminating the chronic atrial fibrillation associated with atrial septal defect and Ebstein's anomaly.

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