Long-Term Recurrence of Atrial Fibrillation After Mitral Valve Replacement and Left Atrial Ablation (Reasons and Mechanisms)

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Summary

Dilatation of the left atrium due to the mitral valve disease is one of the main reasons for the development of atrial fibrillation (AF). Arrhythmogenic zones within the left atrium may be isolated from the interatrial septum and the right atrium by radiofrequency (RF) ablation. Such ablation procedure would be a logical addition to the surgical correction of mitral defects for patients with chronic AF. The objective of our study was to determine the causes and mechanisms of recurrent AF after left atrial ablation. RF ablation of the left atrium was performed in 29 patients with rheumatic mitral valve disease and chronic AF (4 males, 25 females with a mean age of 47.2 ± 10.1 years). The main reasons for AF recurrence in patients with left atrial ablation after mitral valve replacement were right atrial dilatation and structural changes of the right atrial myocardium.

Key Words

Atrial fibrillation, mitral valve replacement, radiofrequency (RF) ablation

Introduction

Atrial fibrillation (AF) is a common complication of mitral valve disease (MVD), aggravating the functional status of the patient in the long-term postoperative period, and inducing a high risk of thromboembolic complications. The unsatisfactory outcomes of conventional therapies have encouraged the search for surgical techniques to treat more effectively the given complication. One of the first methods for the surgical treatment of AF was left atrium (LA) isolation, i.e., radiofrequency (RF) ablation, introduced in clinical use by Williams in 1980 [1] and modified by Bokeria in 1981 [2]. The aim of this intervention is to isolate arrhythmogenic zones of the LA from the interatrial septum (IAS) and from the right atrium. As dilatation of the LA due to MVD creates to a substrate that favors development of AF, the aforementioned RF procedure would be a logical addition to the surgecal correction of mitral defects in patients with chronic AF. In practice, the efficacy of LA ablation for preventing the recurrence of AF in this category is rather low and, according to literature, it varies from 44% to 81% [3,4]. The objective of our study was to determine the causes and mechanisms of recurrent AF after left atrial ablation.

Materials and Methods

RF ablation of the LA (Figure 1) was performed in 29 patients with rheumatic MVD and chronic AF (4 males, 25 females with a mean age of 47.2 ± 10.1 years). All of them were categorized as NYHA Class IV before the operation. The mean diameter of the LA in this group was 56.7 ± 8.2 mm (from 46 mm to 78 mm). The systolic pressure in the pulmonary artery was 52.3 ± 12.4 mm Hg. Extrasystole at rest was recorded in 19 patients (73%). All patients received antiarrhythmic drugs before the operation. b-blockers were the most often used drug (23 patients, or 89%);

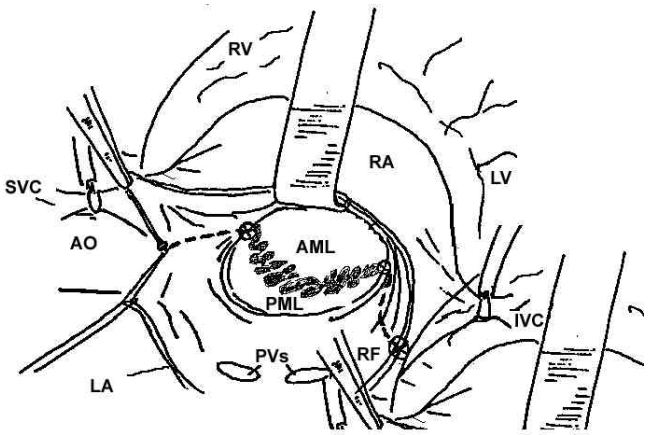


Figure 1. Radiofrequency isolation of the left atrium (scheme). AO – aorta, SVC – superior vena cava, PML – posterior mitral leaflet, LV – left ventricle, LA – left atrium, IVC – inferior vena cava, RV – right ventricle, RA – right atrium, AML – anterior mitral leaflet, RF – lines of the RF-destruction of the left atrial wall, PVs – ostias of the pulmonary veins.

Cordarone was given to 2 patients (8%), and Verapamil to one patient (4%). Five patients had undergone previous cardiac surgery, one of them already thrice.

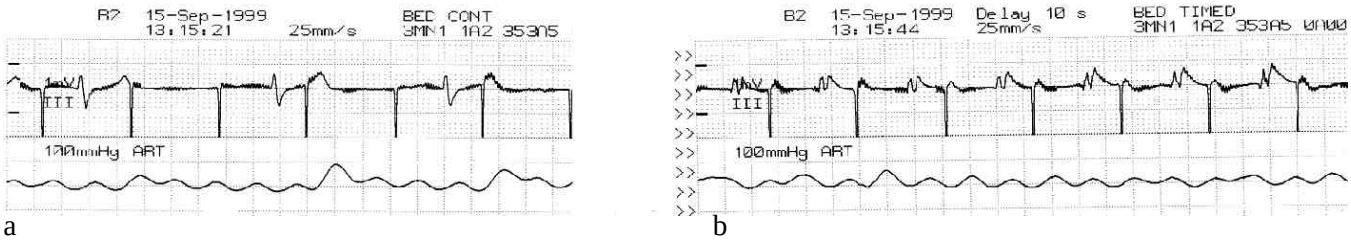
To 22 patients, the mean value of the AF anamnesis was 37.5 ± 12.4 months (seven of the examined patients could not indicate the exact time of the persisting arrhythmia). During an anamnesis, five patients experienced sequences of cerebral stroke: one patient with an expressed neurological deficit – right-handed hemiparesis and aphasia), four without a significant residual neurological defect. One patient had LA thrombosis.

All operations were performed under conditions of an cardiopulmonary bypass and cold crystalloid cardioplegia. The diseased mitral valve was replaced by a mechanical disk prosthesis (MIKS, "Roskardioinvest", Russia) or a bicuspid prosthesis (Sulzer Carbomedics, USA), using common techniques. Concomitant lesions of valves and cardiac arteries were found in 19 patients (73%): tricuspid insufficiency in 15 patients (58%), aortal valve lesions in three patients (12%), and coronary artery disease in one patient (3%).

An RF generator (RF-50epi, Electropulse Medical Industries, Russia) was used for the LA ablation. The mean time for RF ablation of the LA was 13.6 ± 3.2 min, with a power level of 15 to 35 W (on average 30.4 ± 2.5 W). LA ablation was completed in 20 patients; nine patients experienced unsuccessful results (three patients died in the early postoperative period – two of acute heart failure and one of erosive aortic bleeding due to necrotic mediastinitis). The surviving patients with unsuccessful surgical results were eliminated from the study. The effectiveness of the LA ablation was proven by a LA pacing test using electrical stimulation (Figure 2). In total, 20 patients after mitral valve repair with complete LA ablation are now in follow-up. The mean follow-up period after the operation at the time of the monitoring examination was 23.1 ± 4.2 months.

Results

At the time of examination, 14 of the 20 monitored patients had a sinus rhythm (70%). One patient experienced chronic atrial flutter. The remaining five patients had AF at the time of examination. Out of the 14 patients, who showed sinus rhythm at the time of examination, 13 patients had AF paroxysms in the early postoperative period. Full LA ablation had been performed for all patients in this subgroup. All 13 patients underwent cardioversion: six of them prior to being discharged from the hospital, and seven 4 – 6 months after being discharged. AF did not recur in seven patients, and seven had AF paroxysm within the first year after cardioversion. Drug cardioversion with Chinidinum was effective for five patients, and two underwent repeated DC shock cardioversion. In all, seven patients were given Cordarone in order to pre-



a b

Figure 2. Pacing test of the left and right atria. Panel a) left atrial pacing; panel b) right atrial pacing.

	Without AF Paroxysms (n = 7)	With AF paroxysms or persistent AF (n = 7)	p-value
Left atrial size (mm)	51.3 ± 5.2	53.2 ± 4.2	ns
Left ventricular end-diastolic diameter (mm)	52.3 ± 4.3	54.1 ± 3.9	ns
Left ventricular ejection fraction (%)	61.2 ± 6.4	59.1 ± 5.3	< 0.05
Mean grade of tricuspid insufficiency	1.2 ± 0.3	2.1 ± 0.4	< 0.05
Right atrial size (mm)	42.3 ± 3.4	53.1 ± 5.1	< 0.05
Right ventricular antero-posterior size (mm)	25.2 ± 3.4	26.1 ± 3.1	ns

Table 1. Clinical data of the patients in the long-term period after mitral valve replacement and complete left atrial isolation, mean ± standard deviation.

Postoperative	1th day	3th day	7th day
Wenckebach rate (beats/min)	210.0 ± 49.5	185.7 ± 8.1	190.0 ± 9.3
AV-node refractoriness (ms)	230.0 ± 27.8	239.7 ± 55.7	270.0 ± 24.8
Right atrial refractoriness (ms)	176.8 ± 8.7	187.6 ± 24.3	197.6 ± 23.7
Sinus node function recovery time (ms)	2015 ± 96	179.3 ± 126	1634 ± 177
PQ interval (ms)	184.5 ± 34.4	155.5 ± 12.0	166.0 ± 11.6

Table 2. Electrophysiological parameters of the right atrial wall and AV junction area in patients after mitral valve replacement and complete left atrial isolation, mean ± standard deviation, (n = 16).

vent AF recurrence, which they continue to take in an appropriate dosage.

In the long-term postoperative period, practically all patients with a restored sinus rhythm experienced positive changes of the main clinical findings. However, it should be noted that several patients in this group had a decreased size of the right atrium (RA), whereas residual tricuspid regurgitation and the size of the right ventricle did not significantly decrease after the surgical correction of the MVD. As indicated above, the RA of all these patients contracted in a sinus rhythm, which, in our view, resulted in a decrease of its volume in the postoperative period. With the improvement of the right heart function, the patients who underwent LA ablation exhibited a marked improvement of left ventricular contractility, probably due to normalization of the left ventricular diastolic function.

Due to the increased blood flow through the left AV valve and improved diastolic function of the left ventricle after the correction of the cardiac rhythm, we also see a significant reduction of pressure in the pulmonary artery. However, despite the improvement of intracardiac hemodynamics after LA ablation, its diameter had not markedly decreased. The cluster analysis conducted in this group has allowed us to differentiate patients according to their RA diameter, which appeared significantly higher for patients with chronic or paroxysmal AF in the long-term period after LA ablation. When comparing this subgroup of patients with a group of patients with stable sinus rhythm after LA isolation, we noticed not only a markedly greater RA size, but on average also a higher level of tricuspid regurgitation (Table 1).

In order to determine the causes of AF recurrence in patients after LA ablation in the early postoperative period (1, 3, 7 days after surgery), we studied changes of the electrophysiological characteristics of the RA and the area of the AV junction (Table 2). We detected no significant differences in the observed electrophysiological parameters at the checked locations. The structural changes of the auricle wall can be explained by linear shortening of the RA effective refractory period, which increases the probability of the occurrence of fibrillation.

We had noticed the presence of electric RA vulnerability, which was expressed by a decrease of the effective refractory period of the sinoatrial area by up to 187.6 ± 24.3 ms with consequent signs of an increase. Thus (even if there is a tendency to an increase), differences between the RA effective refractory period and the AV node increase, which, in turn, can lead to the development of AF due to the presence of a "maternal wave" or extrasystoli.

According to the surface ECG (PQ interval) data, a retardation of the depolarization at the AV node area is not significant. Moreover, up to the seventh day of the postoperative period, we detected a tendency towards acceleration. We consider postoperative therapy by means of corticosteroids to be useful for the suppression of initial inflammatory phenomena in certain elements of the conductive system in the AV junction area.

The group of patients with MVD and chronic AF had a long anamnesis of an arrhythmia that suppressed the

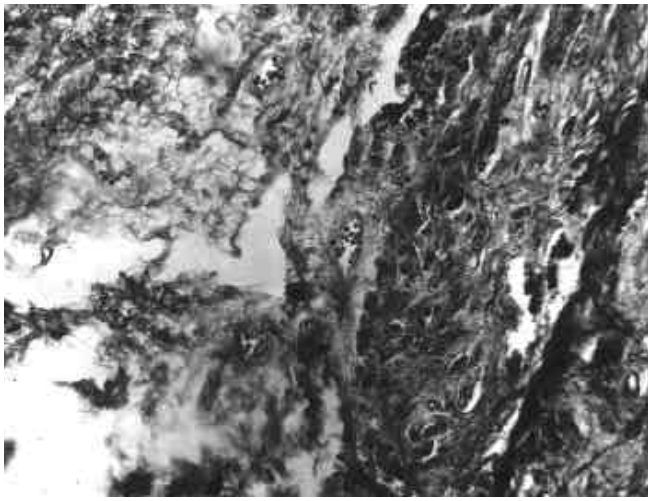


Figure 3. Site of tricuspid annulus destruction and perian-nular granuloma (hematoxylin-eosine, 400x magnification).

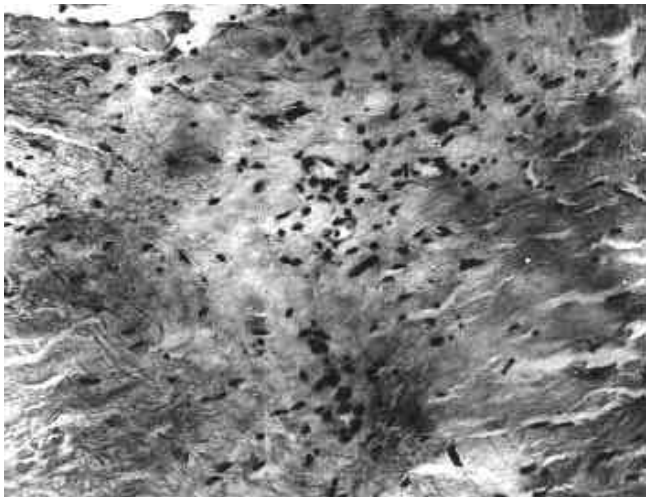


Figure 4. Destruction of the right ventricular myocardium near the AV junction area (hematoxylin-eosine, 200x mag-nification).

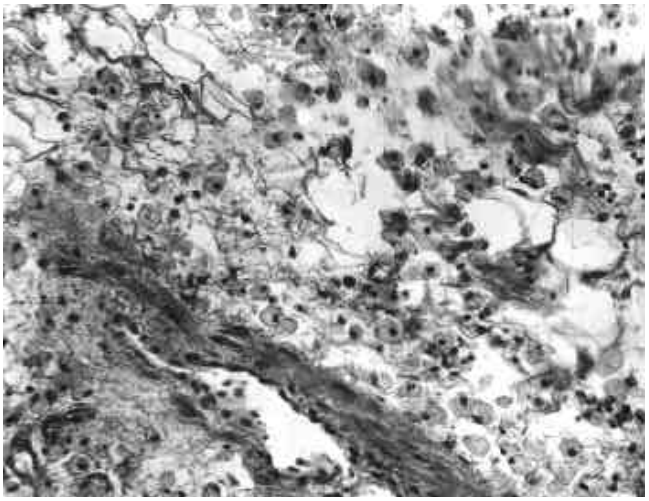


Figure 5. Section of the conducting system of the heart (AV-node area): infiltration by lymphocytes and plasma cells (hematoxylin-eosine, 400x magnification).

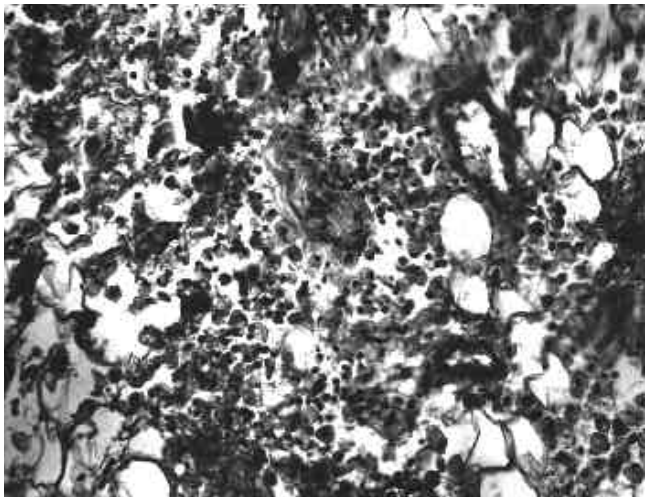


Figure 6. In the sinoatrial node area the inflammatory phe-nomena were expressed more weakly, but the elements of the conductive system were considerably rarefied (hematoxylin-eosine, 400x magnification).

sinus node function. According to our data, all these patients experienced a dysfunction of the sinoatrial node in the form of a sinus bradycardia or a "sinus arrest" phenomenon with an alternating rhythm from AV junction in the early postoperative period. This is confirmed by the increased sinus node function recov-ery time of up to 2015 ± 96 ms, which was recorded to be within the limits of pathological values during the entire early postoperative period in all patients and demanded temporary AAI pacing.

The majority of these patients had suffered to varying degrees from fissile rheumatic carditis before surgery. It would be logical to assume that along with the rheumatic lesions of the cusps and subvalvular struc-tures of the mitral valve, as well as the myocardium, the rheumatic process affected the myocardium of both atria, not excepting the area of the sinoatrial and AV nodes. Therefore, we performed histological research of the right atrial wall, interatrial septum, and AV junc-tion area in those patients who died after prosthetic repair of the mitral valve.

During the autopsy of the three deceased patients, we took tissue samples for histological research: sections of the sinoatrial zone and areas of the AV junction. The

mean age of these patients was 45.7 ± 12.4 years (30 to 60 years). In all cases, at the time of the operation there was MVD of a rheumatic etiology with a predominance of stenosis and absence or minimum activity of the rheumatic process. The specimen were fixed in 10% formaldehyde, filled up with paraffin, then imbued with hematoxylin-eosine by Mallory's method [5].

In one case, we ascertained granulation sites near the disorganized tricuspid annulus of the valve in the area of the AV junction (Figure 3). The myocardium of the right ventricle near the AV node had signs of inflammatory destruction due to rheumatic disease (Figure 4). The inflammatory process affected the conducting system of the heart, exhibiting marked infiltration by lymphocytes and plasma cells and destruction of conductive myocytes (Figure 5). In the sinoatrial node area, the inflammatory phenomena were expressed more weakly (Figure 6), but the elements of the conductive system were considerably rarefied.

Conclusion

The main reasons of AF recurrence in patients with isolated LA after mitral valve replacement are:

- RA dilatation due to marked persistent tricuspid insufficiency in the long-term postoperative period;
- Structural changes of the myocardium of the RA and elements of the specialized conductive system of the heart due to chronic inflammatory processes that result in changes of the RA and AV junction area electrophysiology, enhancing its arrhythmogenic "readiness"

These factors impede the effective attainment of sinus rhythm stability in the long-term period after LA ablation.

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