

Radiofrequency pulmonary veins isolation of atrial fibrillation in patients undergoing mitral valve replacement

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Received 10 December 2006; accepted 28 February 2006

Abstract: Introduction: Pulmonary veins isolation (PVI) is useful method in patients (pts) with mitral valve disease (MVD) and chronic atrial fibrillation (AF) during prosthetic valve implantation.

The aim of the study: To evaluate effectiveness of PVI in the treatment of AF in pt with MVD during valve implantation.

Material and methods: 45 pts (mean age 55 yrs) with AF were operated on for MVD. RF ablation around the pulmonary veins, a lesion between them and to the mitral annulus were performed. There were 44 prostheses implanted, 1 case of mitral valve annuloplasty, associated with tricuspid valve repair (5 pts), aorto-coronary bypass procedure (2 pts), ASD II closure (1 pt).

Results: SR was achieved in 2 (44,5%) pts, 21 (46,5%) pts were in AF, 4 (9%) pts needed pacing. No correlation between SR restoration and preoperative echocardiographic parameters, age, gender, NYHA functional class were found. In long-term follow-up 1 pt have reversed AF to SR spontaneously. There were 6 cases of paroxysmal AF, 1 pt needed pacemaker implantation. 20 (44,5%) pts are in SR, 20 (44,5%) in AF, 5 (11%) in permanent pacing.

Conclusion: PVI with RF use is effective in restoring sinus rhythm in patients with chronic AF secondary to mitral valve disease.

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Keywords: Mitral valve disease, atrial fibrillation, pulmonary veins isolation

1 Introduction

Chronic atrial fibrillation (AF) is the most common sustained arrhythmia in the general population and especially in patients with mitral valve disease (MVD)[1, 2]. It can be causative mechanism of symptomatic tachycardia and low cardiac output syndrome. The risk of thromboembolic complications in patients with AF is about 5-10 % [2]. AF is also thought to be associated with poorer survival rates compared to patients with sinus rhythm (SR) [1, 2].

Since 1987, when Cox et colleagues have presented maze technique for treatment AF, efforts were made to achieve less invasive methods to be useful in association with mitral valve operation [3]. In 1998 Haissaguerre described foci located in pulmonary veins (PVs) as triggers of AF [4]. Melo et al. were the first who introduced RF ablation as a method of pulmonary veins isolation (PVI) for treating chronic AF [5, 6]. Nowadays intraoperative surgical RF ablation became a new, promising method for sinus rhythm restoration.

Based on this consideration, we performed a study to evaluate the effectiveness of RF ablation as a method of PVI in the restoration of sinus rhythm in a group of MVD patients.

Institution's ethics committee approved the study. Informed consent was acquired from each individual included in the study.

2 Material and methods

Between January 2000 and December 2004, 45 patients with chronic AF and MVD underwent mitral prosthesis implantation associated with PVI. There were 9 men and 36 women, mean age was $59,9 \pm 5,5$ years. Patients' characteristics and concomitant diseases are shown in Table 1.

All patients underwent chest X-ray, electrocardiograms, echocardiograms and coronaryography examination. The patients fulfilled both clinical and hemodynamic criteria for mitral valve replacement.

The exclusion criteria for RF PVI were: AF lasting less than 3 months, hyperthyreosis, alcoholism, nonagreement with protocol inclusion.

2.1 Surgical procedure

The same surgical team operated all patients on. In all cases the medial sternotomy was performed, pericardium was opened longitudinally. Cardiopulmonary bypass was established by ascending aorta and bicaval cannulation. The aorta was clamped and blood cardioplegic solution was infused through root of ascending aorta. Patients were cooled to 32 °C. Atria were opened by Guirardon incision. The mitral leaflets were excised (the posterior leaflet was preserved if it was possible), and single sutures were

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Table 1 Preoperative patients' characteristics.

Number of patients	45
Male/female	9/36
Age (years)	36-75 (mean 59,9,±5,5)
Type of valve disease	N.of pts
• Mitral stenosis	-8
• Mitral regurgitation	-7
• Mitral stenosis combined with mitral regurgitation	-30
NYHA functional class	N of pts
• I	-1
• II	-7
• III	-31
• IV	-6
AF duration	3 months- 20 years (mean 5,1 years)
Concomitant diseases	
• Arterial hypertension	7
• Chronic obstructive pulmonary disease	2

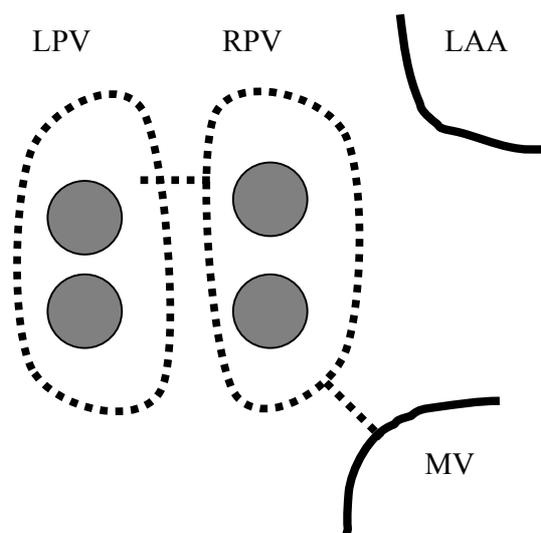
laid on the mitral annulus. At this point the valve implantation was interrupted and PVs RF isolation was performed.

To perform radiofrequency (RF) ablation lesions the Cobra device (Boston Scientific Corporation) was used. The system consists of a flexible surgical probe with seven electrode terminals for separate or combined use (which create continuous linear lesion), a generator of RF energy, an ablation controller and connecting cables.

RF ablation was performed by creating an encircling lesions around the right and left pulmonary veins, a lesion between them and a lesion from this encircling lesion to the mitral annulus (Fig. 1). Ablation was performed using RF power for 2 minutes, the local temperature was set at 70 °C. Electrophysiology examination to confirm conduction block were not performed during surgery.

Than mitral valve prosthesis implantation was continued typically. The aortic clamp was opened and myocardium was reperfused. After rewarming bypass was terminated, the cannulas withdrawn, temporary pacing wires placed over right ventricle, and sternotomy closed.

There were 43 St.Jude Medical and 1 Medtronic-Hall mechanical prostheses implanted in mitral orifice, 1 case of mitral valve annuloplasty with Duran ring, associated with tricuspid de Vega annuloplasty (5 pts), coronary artery bypass grafting (CABG) (2 pts), ASD II closure (1 pt), aortic valve implantation (1 pt) (Table 2).



LPV- left pulmonary veins, RPV- right pulmonary veins, LAA- left atrial appendage, MV- mitral valve

Fig. 1 Pulmonary veins isolation.

Table 2 Summarised surgical data.

Operative data	Number of pts
St.Jude Medical valve prosthesis	43
Medtronic-Hall mitral valve prosthesis	1
Mitral valve annuloplasty	1
Concomitant tricuspid valvuloplasty	5
Concomitant atrial septal defect closure	1
Concomitant CABG	2
ECC time (minutes)	60-148 (mean 91)
ACC time (minutes)	47-127 (mean 69)

Lifelong anticoagulation was initiated in all patients because of mechanical heart valves.

2.2 Postoperative management

Two weeks and 6 months after surgery clinical examination, standard 12-lead electrocardiogram (ECG) and transthoracic echocardiogram (TTE) were performed in all patients in the same hospital's outpatients department.

2.3 Statistical analysis

The data are shown as mean \pm standard deviation. Comparison of the parameters between groups of patients was tested by the Student's t-test. In order to differentiate

parameters correlated with sinus rhythm restoration multiple regression was performed and Pearson's correlation coefficient was calculated for linear variables and Spearman's rank coefficient for nonlinear variables. Statistical significance was defined as $p < 0,05$. All data were analyzed using the statistical software package Microsoft Excel.

Informed consent was obtained from all patients before participation in the study and the protocol was approved by the Ethics Committee of the Institute of Cardiology in Warsaw.

3 Results

There were no severe postoperative complications and no hospital mortality. The aortic cross-clamping time was 47-127 minutes and the extracorporeal circulating time was 60-148 minutes. Surgical data are shown in Table 2.

During the postoperative period 4 pts underwent pacemakers implantation (3 VVI, 1 DDD type) due to slow junctional rhythm or complete atrio-ventricular block during atrial fibrillation.

The ECG analysis on time of discharge shown sinus rhythm in 20 (44,5 %) of patients, atrial fibrillation in 21 (46,5 %) patients and 4 (9 %) pts were on permanent pacing (Fig. 2). Echocardiographic analysis performed on discharge shown no differences between left ventricular parameters. Only left atrium diameter reduction after procedure was statistically significant (Table 3). We found no statistical correlation between sinus rhythm restoration and: age, gender, NYHA functional class and echocardiographic parameters (Table 4).

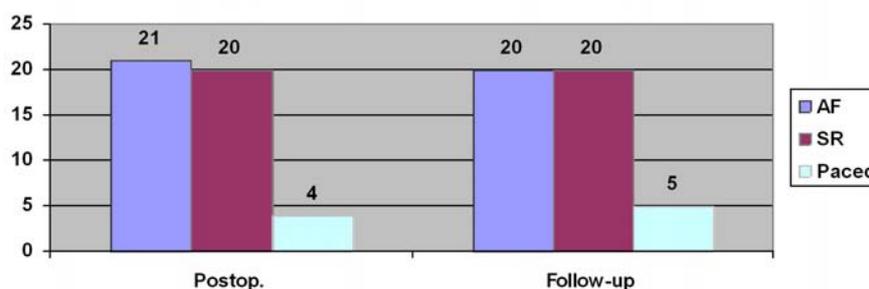


Fig. 2 Type of heart rhythm after procedure and in long term follow-up.

There are 45 pts on long-term follow-up. Time of observation was 6-56, mean 17 months. Twenty (44,5 %) pts are on sinus rhythm, 20 (44,5 %) on AF, 5 (11 %) pts have paced rhythm (3 VVI, 2 DDD type) (Fig. 2). In 1 patient pacemaker implantation following a-v junction ablation was performed due to recurrent atrial fibrillation. During observation in 1 patient AF reversed spontaneously to SR. There were 6 cases of paroxysmal AF: 4 were reversed to SR (1 pharmacologically, 2 by electrical cardioversion, 1 spontaneously). In 6 pts rhythm changed to AF (1 reversed then to SR).

Table 3 Preoperative and follow- up echocardiographic data.

	Before surgery		After surgery		P
	range	mean	range	mean	
LVDD (cm)	3,4-7,8	5,2	4,1-5,6	4,9	NS
LVSD (cm)	2,1-6,9	3,47	2,4-4	3,1	NS
LVEDV (ml)	47-335	119,6	74-153	107,8	NS
LVESV (ml)	14-247	53,2	20-70	39,3	NS
EF (%)	46-81	62,04	40-74	61,9	NS
LA (cm)	4,3-7	5,34	4-5,4	4,6	<0,05
MMG (mmHg)	8,7-32	15,7	6-20	12,1	<0,05
Mmg (mmHg)	3-21	7,4	2-8	4,36	<0,05
MVA (cm ²)	0,6-1,9	1,21			

LVDD- left ventricular diastolic diameter, LVSD-left ventricular systolic diameter, LVEDV-left ventricular end-diastolic volume, LVESV- left ventricular end-systolic volume, EF- left ventricular ejection fraction, LA-left atrium diameter, MMG- maximal mitral gradient, mmg- mean mitral gradient, MVW- mitral valve area

Table 4 Statistical correlation between SR restoration and preoperative echocardiographic parameters.

	Value	r	
LVDD (cm)	5,1 +/- 0,5	-0,1841	NS
EF (%)	62,5 +/- 6,3	0,4306	NS
LA (cm)	5,36 +/- 0,48	-0,1936	NS
Mmg (mmHg)	7,57 +/- 2,5	0,0773	NS
MVA (cm ²)	1,21 +/- 0,2	0,0290	NS
PASP (mmHg)	37,4 +/- 9,8	0,2085	NS
Age (years)		0,2841	NS
Gender		0,1846	NS
NYHA class		-0,2258	NS
Concomitant diseases		-0,21	NS

4 Discussion

Persistent atrial fibrillation in patients after mitral valve replacement decreases beneficial influence of the procedure and improvement of effort toleration. Permanent AF has multiple clinical consequences. The loss of atrial contraction and rapid ventricular rate (symptomatic tachycardia) are causes of poorer heart hemodynamic parameters and lead to reduced cardiac output (approximately 20 %). AF is also associated with 5 to 10 % higher risk of thromboembolic complications (risk of stroke, higher rate of death) [7, 8].

The mitral valve disease (stenosis, regurgitation or both) is associated with remodeling

of the atria which leads to its enlargement, which is a risk factor for AF [9, 10]. As a consequence of MVD about 9 % presented paroxysmal, and 75 % persistent AF [11].

In last decade many research centres have made efforts to achieve methods of SR restoration in patients with AF undergoing cardiac operations. Some of these procedures tried to combine mitral valve operation with antiarrhythmic procedure.

In 1962 Moe presented concept of multiple wavelet hypothesis to explain the pathophysiology of AF [12]. Next Allesie indicated that only 6 wavelets are necessary to sustain AF [13]. Based on this theories Cox et colleagues proposed in 1987 the maze procedure as a invasive method for treatment AF [3, 14]. The procedure depends on forming block for reentrant wavelets by complex incisions [14]. In 1990s it was confirmed, that RF energy could be used for surgical ablation to create transmural atrial lesions [15]. RF ablation is a procedure where high frequency energy ($> 500.000\text{Hz}$) is delivered into cardiac tissue to cause thermal injury to the arrhythmogenic site and render this tissue electrically inactive. The thermal injury occurs when cardiac cell are heated above $50\text{ }^{\circ}\text{C}$. There are two types of RF ablation- temperature control and fluid cooled. Both methods are successful in the treatment of supraventricular and ventricular arrhythmias [16].

In the beginning RF technique was used to percutaneous ablations, then it was introduced to operative procedures. Intraoperative surgical catheter ablation became a challenge for the treatment of AF in combination with open-heart surgery.

Since the time, when Cox et al [3] have used the maze procedure for treatment AF, this technique was thought to be useful in association with mitral valve operation. In recent years many centres were combining mitral and maze procedures with a success rate of 85-98 % of recovering atrial rhythm after mitral valve operation [5, 17, 18]. Operative maze procedure (by Cox), which significant part is to isolate all four pulmonary veins from the rest of LA, has evolved towards a shorter and less invasive procedure. Ablation tools with microvave, laser, cryotherapy and ultrasound are used nowadays for creating the lines of conduction block. Minimally invasive epicardial surgical approaches through 1cm port access incisions are currently undergoing clinical evaluation [19].

In 1998 Haissaguerre described that the initiation of AF originates from firing foci located inside pulmonary veins (PVs) [4]. In utero PVs receive a sleeve of atrial muscle as they bud out from the heart to the lungs. This sleeve of atrial muscle in the proximal pulmonary veins may become active and show spontaneous discharge in later life, triggering episodes of AF [19]. According to that, the concept was developed that PVs isolation should be basis for surgical RF ablation procedures [4]. Melo et al. were the first who introduced RF ablation for PVI in patients with atrial fibrillation. Nowadays this procedure is thought to be promising method of SR restoration in patients with AF. PVI is performed as a additional procedure during many cardiac operations, eg.: CABG, valve implantation.

Patients with mitral valve disease (MVD) and AF are very peculiar group. The majority of patients operated on for MVD with chronic AF do not recover SR with conventional treatment [20, 21].

Kalil et al. performed a retrospective study on 100 pts operated on for MVD in

chronic AF. The return of SR was analysed with relation to age, gender, AF duration, LA size, left ventricular ejection fraction (LVEF), valve procedure, associated procedures and reoperation. In this group, in over 1 year follow-up after mitral valve operation only 26 % patients presented SR, whereas 74 % remained in AF. The analysis demonstrated, that the mitral stenosis (MS) was a risk factor for maintaining AF, whereas regurgitation (MR) was more associated to SR recovery (in MS group 17 % of SR, in MR 44 %, $p < 0,05$). There were no relations with other parameters and SR restoration [2].

Chua et al. studying outcome of mitral valve repair in pts with preoperative AF reported 80 % persistence of AF. Large LA size correlated weakly with late AF. No other factors correlated with late postoperative rhythm [22].

In other paper Flugelman et al. reported evidence, that restoration and maintenance of SR after MVR for MS was not achieved in patients with symptoms lasting longer than 3 years, with LA size more than 52 mm [23].

In our paper we also found no correlation of SR restoration and age, gender, NYHA functional class, concomitant diseases and echocardiographic parameters.

Operative maze procedure has evolved towards a shorter and less invasive procedure. PVI with RF use is effective method in patients with chronic AF secondary to mitral valve disease and compared to maze procedure show similar results in the restoration of sinus rhythm [1]. Tanaka et al. applied PVI technique in 13 pts undergoing MVR. 84 % pts returned to SR, 3 pts required DDD pacemaker implant for sick sinus rhythm [24].

Suead et al. performed PVI with using computerized 48-channel mapping system in 12 pts. 9 (75 %) of pts successfully returned to SR [25]. Sankar et al. connected the technique of LA reduction and PVI. In this group 86 % of AF with MVD came back to normal SR. They thought, that LA reduction in addition to PVI is effective in restoring SR [26].

In our series 44 % pts reversed to sinus rhythm after operation. Long lasting MVD and AF probably cause this small amount of successful procedures.

During postoperative period AF could return. Williams et al. reported that 67 % of pts undergoing PVI had at least one episode of AF in the postoperative period. They treated all this arrhythmias with amiodarone, and 76 % pts were in SR at 6 month after surgery [27]. In our group 12 patients (26 %) had episode of AF and 5 were reversed to SR.

The most frequent postoperative complications are bradyarrhythmias: junctional rhythm, atrio-ventricular block. Atrial bradycardia and junctional rhythm might be explained by the lesion to the atrial or sinus node coronary artery [28]. In our series only 4 pts (9 %) required pacemaker implantation due to bradycardia or atrio-ventricular blocks.

The other group are surgical complications. The most fatal but rare is oesophageal thermal injury. Due to possible complications patients with a thin atrial wall resulting from atrial enlargement should be treated more cautiously (less RF time, lower temperature) [29]. Also it is recommended not to keep the TEE probe in place while connecting the two pulmonary veins circles so as to avoid direct thermal injury to the oesophagus

[29]. In our group there was no one case of surgical complication. After percutaneous PVI symptomatic pulmonary vein stenosis occurs in 2-3 % [30]. There were no PV stenoses in our group. The leak of this complications results from operative technique. The application lines are created 1,5-2 cm from PV orifices.

Anticoagulation of pts undergoing PVI procedures remains controversial. Because of high incidence of AF in the early postoperative period in patients who remain in SR many surgeons recommended 3-6 month of anticoagulation [27]. In patients with implanted mechanical valve prosthesis anticoagulation is lifelong.

5 Conclusions

Radiofrequency pulmonary veins isolation for the treatment of chronic atrial fibrillation secondary to mitral valve disease in patients undergoing mitral valve replacement is a simple and effective procedure.

There is no need of additional incisions apart atriotomy and atrial tissue trauma is slight.

The procedure does not cause any severe postoperative complication.

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