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Original Article

Catheter ablation for atrial fibrillation after an unsuccessful surgical ablation and biological prosthetic mitral valve replacement: A pilot study

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Abstract

Background: Patients with mitral valve (MV) disease and atrial fibrillation (AF) undergo simultaneous prosthetic valve replacement and radiofrequency (RF) ablation procedure; however, this combinational procedure restores sinus rhythm (SR) in only 68–82% of the cases. In patients with ineffective surgical ablation, the use of a biological prosthetic valve might not only be a good choice to perform safe catheter ablation procedure in the left atrium (LA), but also provide a way to discontinue administration of oral anticoagulants. The objective of this study was to assess the efficacy of catheter ablation for AF after MV replacement with a biological prosthesis and an ineffective surgical ablation procedure.

Methods: Ten consecutive patients aged 48 ± 7 years were enrolled in this study. All patients had long-persistent AF associated with a rheumatic valve disease, which was treated by MV replacement with a biological prosthesis and a surgical RF ablation procedure. In the late postoperative period, all the patients had recurrent hemodynamically significant AF, which required repeated cardioversions. From 1 year to 3 years after the surgery, catheter ablation was performed, including reisolation of pulmonary veins (PVs) with the ablation of ganglionic plexi or linear lesions on the roof of the LA and mitral isthmus. The efficacy was assessed at 3 months, 6 months, and 12 months after the procedure.

Results: Restoration of SR during ablation was achieved in all of the cases. In 6–9 months, all the patients were free of arrhythmia. LA stunning manifested by the absence or decrease of the "A" wave in the transmitral flow and the retrograde wave in the PV flow was observed in nine patients with SR. In five of the patients, LA contractile function was restored in 1–6 months. Prosthetic valve dysfunction was not detected in any of the patients.

Conclusion: Catheter ablation is an effective method for AF treatment following an ineffective surgical RF ablation procedure and biological prosthetic MV replacement. The use of bioprosthetic MVs allows for performing safe catheter ablation without subsequent prosthetic dysfunction.

Keywords: atrial fibrillation; catheter ablation; heart valve prosthesis

1. Introduction

Atrial fibrillation (AF) occurs in 40–60% of patients undergoing mitral valve (MV) surgery,[1] and sinus rhythm (SR) is restored in <25% of patients who underwent isolated MV replacement.[2] The traditional approach to this category of patients involves simultaneous MV replacement and

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radiofrequency (RF) ablation procedure; however, this combinational procedure restores SR in only 68–82% of the cases.[3] Repeated open-heart ablation procedures are associated with a high risk of resternotomy and cardiolysis.[4] Catheter ablation might constitute an alternative approach to SR restoration in patients who had an unsuccessful surgical ablation procedure. Although the reported risk of complications is relatively low,[5–7] the majority of interventional arrhythmologists refrain from carrying out such procedures because there is a risk of catheter entrapment in the obturator elements of prosthetic MVs. In these circumstances, the use of a biological prosthetic valve might not only be a good choice to perform safe catheter ablations in the left atrium (LA), but also provide a way to discontinue administration of oral anticoagulants.

The objective of the study was to assess the efficacy of catheter ablation for AF following an ineffective surgical RF ablation procedure and biological prosthetic MV replacement.

2. Methods

Ten patients (aged 48 ± 7 years; 6 females and 4 males) with long-persistent AF associated with a rheumatic valve disease underwent simultaneous MV replacement with a biological prosthetic valve and surgical RF ablation. The mean New York Heart Association (NYHA) class was 2.6 ± 0.4. Data on demographic and clinical characteristics as well as echocardiographic features of the patients are presented in Tables 1 and 2. The primary procedures were performed under extracorporeal circulation and pharmacological cardioplegia. "PeriCor" and "UniLine" (NeoCor, Kemerovo, Russia) prostheses were used in seven and three cases, respectively. The surgical RF ablation procedures were performed using the Cardioblate RF generator (Medtronic, Minneapolis, MN, USA) with unipolar and bipolar electrodes, and it included the following phases: (1) "Box" pulmonary vein (PV) isolation or isolation of the left- and right-sided PVs in pairs; (2) ablation of the "roof" line between the left and right superior PVs in case of isolation of PVs in pairs; (3) ablation of the "mitral isthmus" line between the left inferior PV and MV annulus; (4) LA appendage closure; (5) ablation of the line between the left superior PV and the suture on the amputated LA appendage ostium; (6) ablation of the cavotricuspid isthmus line; and (7) ablation of lines between the cannulation sites and the caval veins.

Table 1
Demographic and clinical characteristics of the patients.

Parameter	Value
Age (y)	48 ± 7
Sex (male/female)	6/4
Stenosis/regurgitation	7/3
Rheumatic etiology	100
Long-persistent AF	100
Patients who underwent valvulotomy/valvuloplasty	20
Concomitant arterial hypertension	0
Concomitant chronic obstructive pulmonary disease	10
Diffuse euthyroid goiter	10
NYHA class prior to surgery	2.6 ± 0.4

Data are presented as % or mean ± SD, unless otherwise indicated.
AF = atrial fibrillation; NYHA = New York Heart Association.

Table 2
Echocardiographic data of the patients before and 6.53 ± 2.31 months after the primary procedure.

Parameter	Before mitral valve replacement and surgical RF ablation	After mitral valve replacement and surgical RF ablation	p[a]
LV end-diastolic diameter (mm)	50–56–64	49–53–58	0.06
LV end-diastolic volume (mL)	125–161–211	115–138–167	0.01
LV ejection fraction (%)	56–63–69	52–60–67	0.039
RV end-diastolic diameter (mm)	16–19–23	17–19–21	0.069
LA diameter in long-axis position (mm)	48–54–59	48–51–56	**0.001**
LA volume (mL)	90–108–124	74–94–103	**0.01**
Mitral orifice diameter by Doppler (cm^2)	10–13–19	21–25–30	0.01
Mean transmitral flow velocity (cm/s)	111–145–150	81–91–108	0.076
Left atrioventricular pressure gradient (mm/Hg)	6.5–10.0–11.1	3.4–4.5–5.8	0.018
RV systolic pressure (mm/Hg)	28–36–46	21–30–33	0.036
RA short dimension in four-chamber position (mm)	40–46–52	40–45–51	0.048
RA long dimension in four-chamber position (mm)	48–56–62	49–52–57	0.08

Data are presented as low quartile–median–high quartile.
LA = left atrium; LV = left ventricle; RA = right atrium; RF = radiofrequency; RV = right ventricle.
[a] By Wilcoxon signed-rank test.

Despite the statistically significant favorable evolution of LA diameter and volume in the late postoperative period (6.53 ± 2.31 months), patients had recurrent hemodynamically significant AF that required repeated cardioversions. In three cases, atypical atrial flutter was also registered on the electrocardiography (ECG).

Catheter ablation was performed 1–3 years after the surgery. Electrophysiological study with LA mapping was carried out in all the cases using CARTO 3 (Biosense Webster, Diamond Bar, CA, USA) navigation mapping system and Biotok-1000 (Biotok, Tomsk, Russia) electrophysiology recording system. The LA was accessed through a transseptal puncture under the control of a transesophageal echocardiographic system. A bipolar amplitude map of LA and PVs was then built in cases with AF, whereas an isochronal map was built for cases with atrial flutter. The RF lesions were made in an irrigated mode (rate, 17 mL/minute) with the power of 35 W and temperature of 45°C using NaviStar ThermoCool and EZ Steer ThermoCool NAV (Biosense Webster) catheters.

The variables were presented as low quartile, median, and high quartile except age, NYHA class, and time intervals, which were presented as means and standard deviations. All the statistical calculations were carried out with the

STATISTICA 10 software package (StatSoft, Tulsa, OK, USA) using Wilcoxon signed-rank test.

3. Results

On average, recurrent arrhythmia occurred 6.53 ± 2.31 months after the surgical procedure. Endocardial electrophysiological study was performed, and LA mapping revealed recurrent AF in all the cases. The total procedural time was 156 ± 37 minutes and the fluoroscopy time was 48 ± 19 minutes. Despite the presence of low-voltage signal, located in previously ablated zones, the most frequent finding was PV reconnection. These gap areas were identified by Lasso catheter recordings without the use of adenosine tests (Fig. 1). Therefore, reisolation of PVs was performed in all cases (Fig. 2). The mean quantity of RF energy application

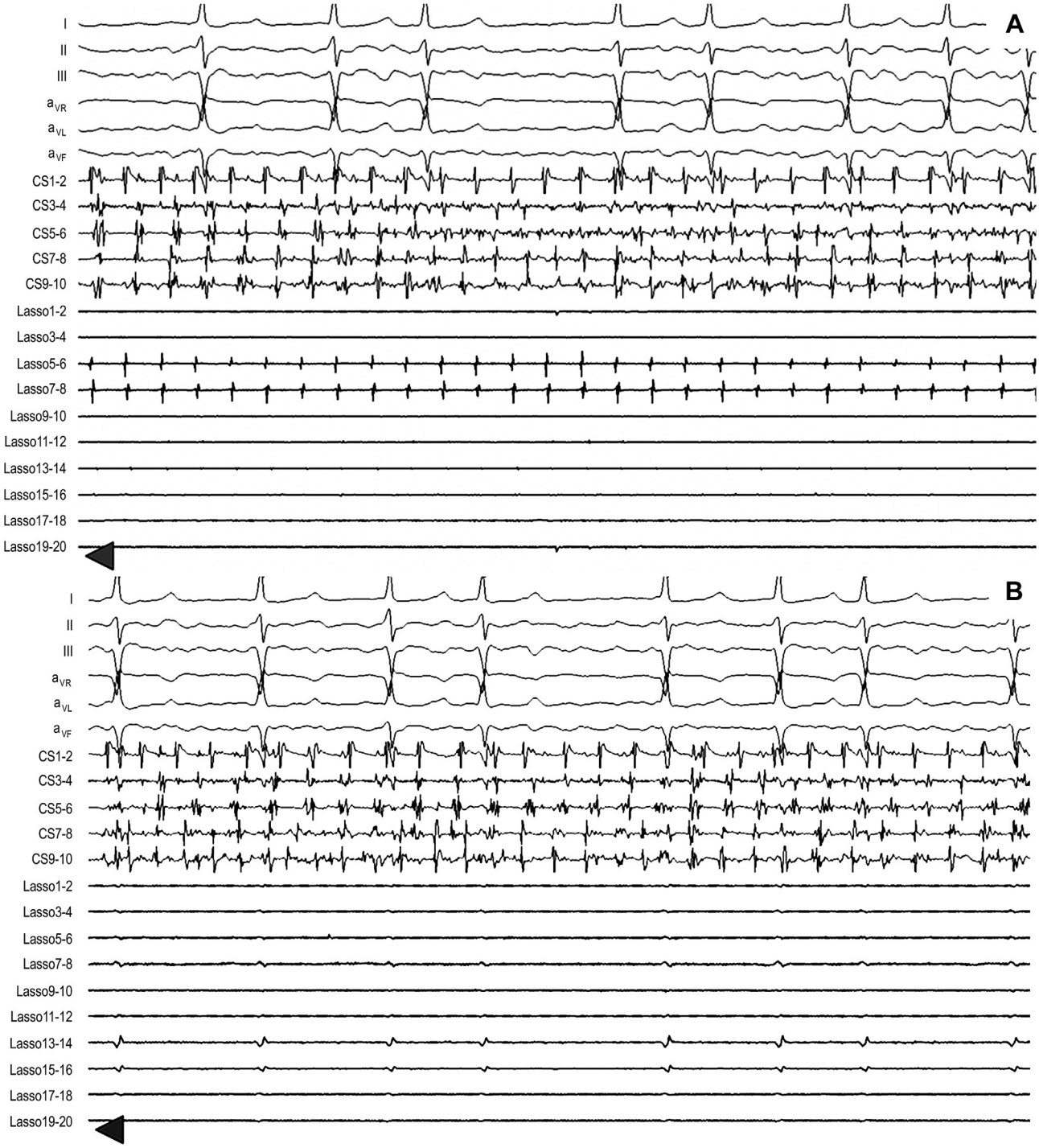

Fig. 1. Reconnection of the lower left pulmonary vein sleeve after surgical radiofrequency ablation. (A) High-frequency signals are registered on the fifth to sixth and seventh to eighth pairs of the Lasso catheter located in the lower left pulmonary vein ostium. (B) After the ablation in the gap area, only ventricular far-field signals are registered on the Lasso catheter recordings. CS = coronary sinus.

required for the closure of gaps in the isolation lines was 12.5 ± 4.6.

The reisolation of PVs led to SR restoration in four of the 10 patients. In two cases, in order to restore SR, the PV reisolation lesions were expanded to the ganglionic plexi areas (Fig. 3). For ganglionic plexi ablation, the anatomical approach described by Pokushalov et al[8] was used. In the other four patients, because AF transformed into an atypical flutter we added linear lesions on the LA roof between the left and right superior PVs, and/or between the right superior PV and the roof line according to the mapping and entrainment data (Fig. 4).

During 3 months of follow-up, IC or III class antiarrhythmic drugs, warfarin, and AT1-angiotensin receptor blockers were administrated to all the patients. The follow-up protocol consisted of physical examination, transthoracic and transesophageal echocardiography, and 7-day ECG monitoring performed at 3 months, 6 months, and 12 months after the catheter procedure. The efficacy of the procedure was reported as the freedom from any atrial arrhythmia >30 seconds. Echocardiography was used to assess the PV blood flow and prosthetic valve function in addition to standard hemodynamic measurements and calculations.

During the treatment period, SR of all the patients was registered at 6 months and 12 months. Immediately after the procedure, atrial stunning manifested in nine cases in the absence of atrial systole in the transmitral blood flow spectrum and the retrograde phase of the PV blood flow (Fig. 5). Six months after the procedure, restoration of atrial contractility was observed in five of the nine patients (Fig. 6), which was the reason for discontinuation of warfarin administration.

4. Discussion

According to the results of this study, the main reason for the lack of success in surgical RF ablation procedure was PV reconnection, and the limited number of lesions required for PV reisolation in the majority of cases. Similar observations were reported both in RF, cryo- or microwave surgical ablations and in a classic "cut-and-sew" technique.[3,9] It is very difficult to estimate the actual number of PV reconnections, because clinically significant recurrent AF occurs only in few cases of reconnection.[3] Even if it happens, the electrophysiology study and reablation are mostly not performed, mainly because of the risks of a repeated open-heart procedure. In case of successful catheter ablation after a mechanical

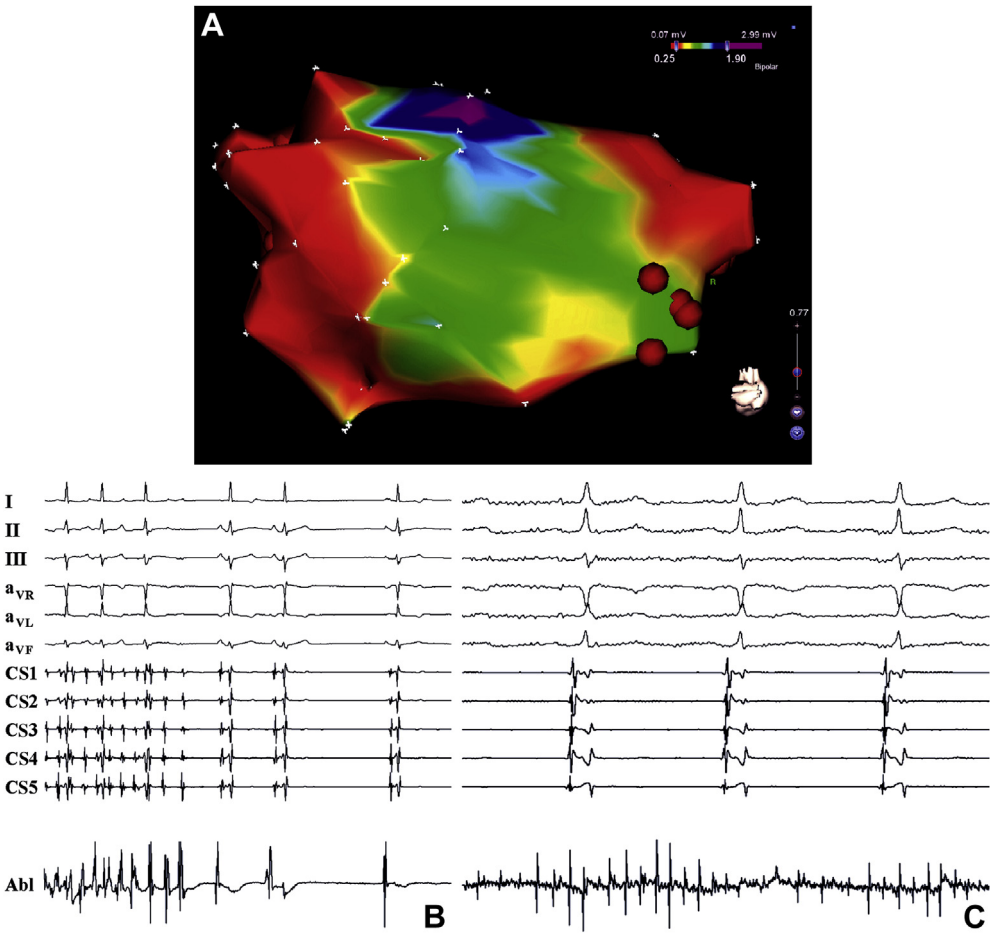

Fig. 2. The first stage of the procedure is pulmonary vein (PV) reisolation. (A) Bipolar isoamplitude map of the left atrium (LA) in the posterior view. The red lines are previously isolated PVs. In the ostium of the right inferior PV, the reconnection region is localized. (B) Very few applications of radiofrequency energy were needed to reisolate PVs and restore sinus rhythm. (C) Ablation/mapping catheter moved into the LA posterior wall, in which isolated fibrillar activity is registered with sinus rhythm. Abl = ablation; CS = coronary sinus.

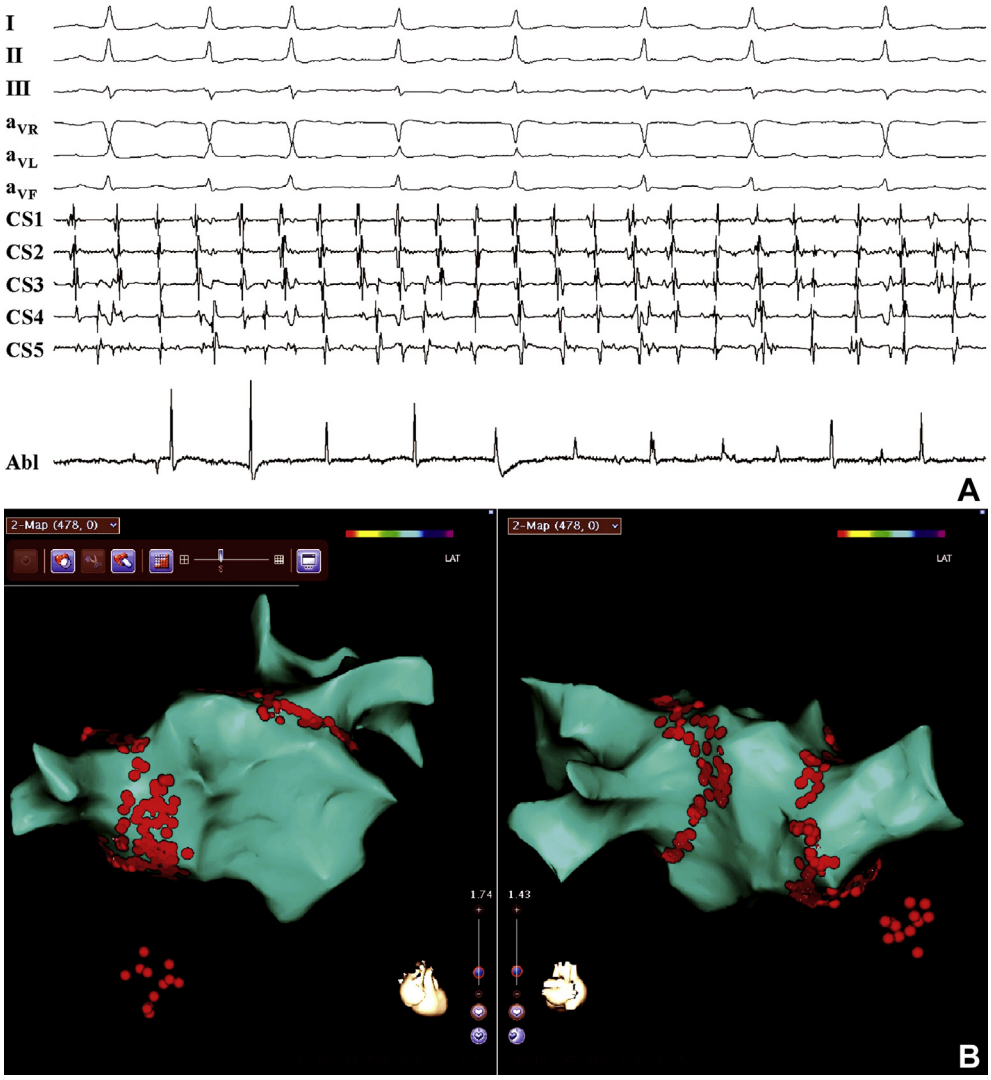

Fig. 3. The second stage of the procedure is the substrate modification by ganglionic plexi ablation. (A) Atrial fibrillation still persists despite complete reisolation of pulmonary vein (PV), confirmed by isolated ectopic activity on the ablation/mapping catheter. (B) In this patient, PV reisolation was combined with ganglionic plexi ablation. Abl = ablation; CS = coronary sinus.

prosthetic valve replacement procedure and ineffective surgical RF ablation, all the patients will be forced to take life-long anticoagulants. Thus, all the advantages of reablation are nullified. In this case, the main benefit of using a biological prosthetic valve is the possibility of discontinuing the anticoagulation therapy after the endothelization of the prosthesis.[10] This opens up the possibilities of not only to restore SR by catheter reablation but also to achieve the main goal of biological prosthetic valve replacement, that is, the freedom from anticoagulants, which, by contrast, might be discontinued once SR is restored. In half of our cases, the combined use of biological prostheses and catheter reablation allowed to achieve the maximum benefit from both procedures.

Our results suggest that reisolation of PV even when combined with ganglionic plexi ablation does not always lead to SR restoration. In several cases, after AF termination, the manifestation of atypical atrial flutter was observed. This is a common side effect of the surgical ablation procedure,[11] arising from the reconduction in linear lesions mostly in the "mitral" isthmus, which is the substrate of perimitral macroreentry, because of slow conduction through gaps in the lines.[9] It is very difficult to make a transmural RF lesion in the thick "mitral" isthmus wall with an open-heart or catheter technique. Therefore, we routinely use the "anterior" mitral isthmus ablation technique, that is, make the linear lesion between the right superior PV and the MV fibrous annulus, which is more easily achievable than the classic "lateral" mitral isthmus ablation.[12] This approach allowed for the restoration of SR in all the cases in our series.

Because the LA appendage was amputated in all the cases of surgical AF ablation, and all the patients had a $CHADS_2$ score of ≤ 2, we discontinued anticoagulation medication in cases with documented good LA transport functions at least 6 months after the procedure. Pet et al[13] were also of the same opinion and they recommended discontinuation of anticoagulation therapy 3 months after the procedure if a patient has no evidence of AF, has discontinued antiarrhythmic medications, and

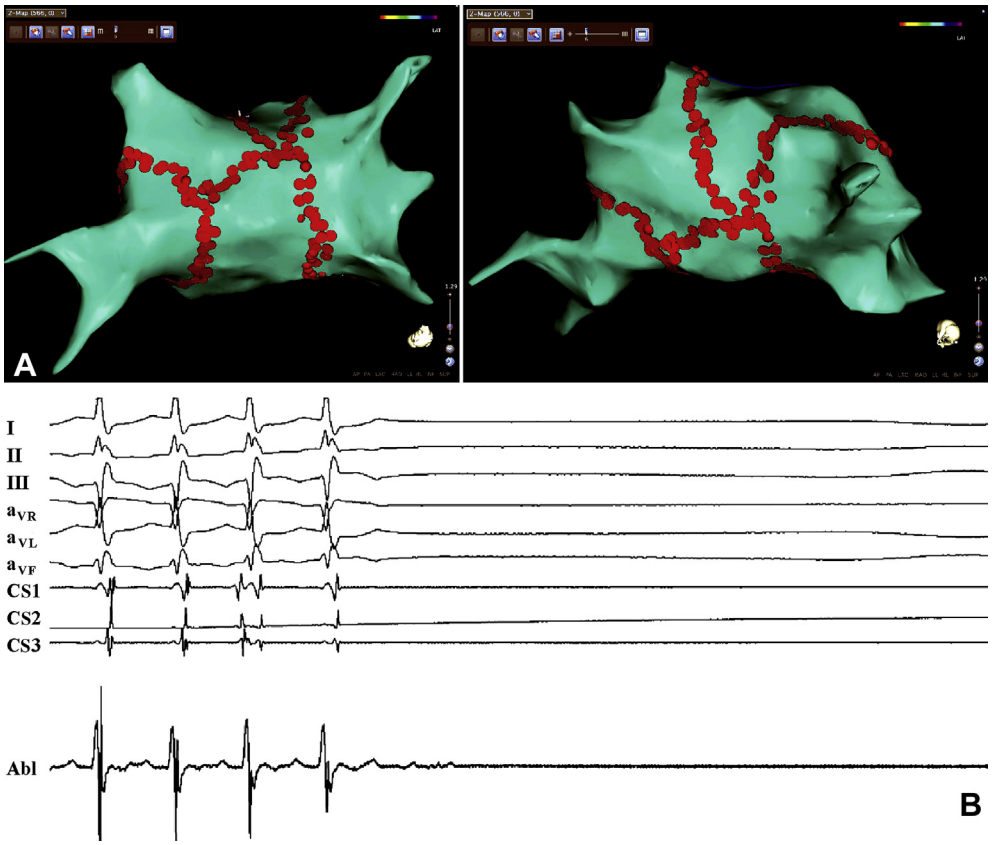

Fig. 4. Catheter ablation of atypical left atrial flutter. (A) Ablation designed to eliminate both perimitral reentry and the reentry around the isolated pulmonary veins. (B) During radiofrequency ablation, atypical atrial flutter is eliminated with asystole as an outcome. Sick sinus syndrome is the most frequent complication of the Cox maze procedure. A permanent pacemaker was implanted in this case. Abl = ablation; CS = coronary sinus.

has no other indication for systemic anticoagulation. Some other authors also stated that permanent systemic anticoagulation seems to be unnecessary in patients with a good atrial transport function after the surgical AF correction.[14,15] Our institute recommends discontinuation of oral anticoagulants 6 months after any type of AF ablation in patients with a biological prosthetic valve, $CHADS_2$ score of ≤ 2, good LA mechanical function, and the absence of AF episodes.

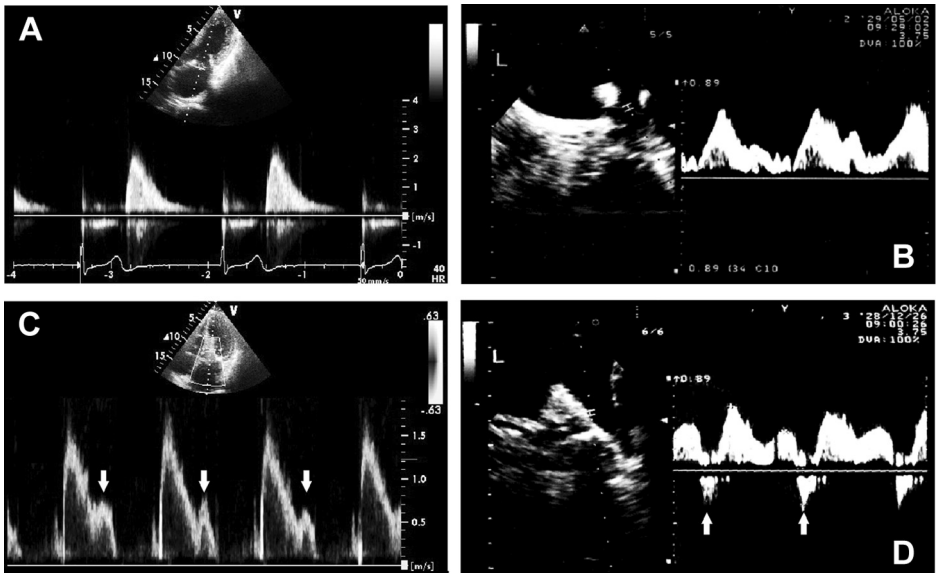

Fig. 5. (A) Left atrial stunning manifested in the absence of atrial systolic peak in the transmitral blood flow spectrum and (B) the retrograde peak Ar in the left inferior pulmonary vein (PV) blood flow spectrum. (C, D) The recovery of the left atrial contractile function manifested in the recommencement of peaks A and Ar (arrows) in the transmitral and PV blood flow, respectively.

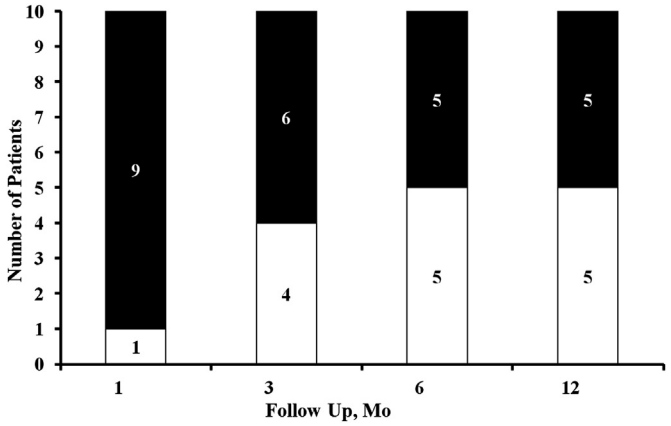

Fig. 6. The left atrial (LA) contractile function dynamics within 12 months of follow up: the black bars are the number of patients with stunned LA, and the white bars show normal LA contractility.

This is a pilot study, and therefore, investigating more cases will allow for developing a more thorough approach for patients suffering from AF after an ineffective surgical ablation procedure and bioprosthetic MV replacement.

In conclusion, catheter ablation is an effective method for AF treatment after an ineffective surgical RF ablation procedure and bioprosthetic MV replacement. The use of biological prosthetic MV allows for performing safe catheter ablation with subsequent anticoagulation therapy discontinuation and without prosthetic dysfunction.

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