Analysis of risk factors for recurrence after video-assisted pulmonary vein isolation of lone atrial fibrillation—results of 5 years of follow-up

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Objective: The purpose of the present study was to assess the efficacy of the long-term results after video-assisted pulmonary vein isolation and left atrial appendage excision for lone atrial fibrillation (AF) and to determine the most significant risk factors for the long-term results.

Methods: From December 2006 to December 2012, 332 consecutive patients with lone AF underwent minimally invasive surgical ablation at our center. Of the 332 patients, 91, who had undergone video-assisted pulmonary vein isolation >5 years earlier, were evaluated in the present study (48 with paroxysmal AF, 21 with persistent AF, and 22 with long-standing persistent AF). The median follow-up period was 66 months. The primary endpoint was the success rate of video-assisted pulmonary vein isolation, defined as the absence of any atrial arrhythmia recurrence lasting >30 seconds at the clinical visit and on the electrocardiogram or long-term cardiac rhythm recording after discharge.

Results: During the follow-up period, 1 patient (1.1%) experienced a stroke and 4 (4.4%) died of noncardiac disease. At the 5-year follow-up point, 43 of 78 patients (55.1%) were in normal sinus rhythm. Of the 39 patients with paroxysmal AF and 39 with nonparoxysmal AF, 27 (69.2%) and 16 (44.1%) were in normal sinus rhythm, respectively. The results of the univariate and multivariate analyses of the preoperative risk factors for AF recurrence showed a left atrial diameter of ≥ 44 mm (hazard ratio, 5.56; 95% confidence interval, 1.68-18.387; $P = .005$) and an AF duration of ≥ 31.5 months (hazard ratio, 3.67; 95% confidence interval, 1.50-8.95; $P = .004$) were the most significant independent risk factors.

Conclusions: Patients with lone AF with a large preoperative left atrial diameter and long AF duration will not be suitable for video-assisted pulmonary vein isolation alone and might need to undergo ablation of the lesions. (J Thorac Cardiovasc Surg 2014;148:2174-80)

Since Haissaguerre and colleagues¹ reported that ectopic beats originating in the pulmonary veins can result in the spontaneous initiation of AF in 1998, concept development in AF treatment has brought about changes in the technology and methods of AF surgery. In 2005, Wolf and colleagues² performed video-assisted pulmonary vein isolation (PVI) on 27 cases of lone AF (LAF) and reported that 97% of the patients were free of AF at early follow-up. Since then, a variety of minimally invasive surgical techniques have been widely applied worldwide. The percentage of success with minimally invasive surgery for AF has ranged from 42% to 95.5% in the published data, with a follow-up period of 6 to 36 months.³⁻¹⁰ We retrospectively analyzed the data from patients who had

undergone video-assisted PVI and left atrial appendage (LAA) excision with >5 years of follow-up at our center, representing one of the rare experiences with 5 years of follow-up.

METHODS

Patient Selection

From December 2006 to December 2012, 332 patients with LAF underwent minimally invasive surgery at the Atrial Fibrillation Center, Beijing Anzhen Hospital. The 91 patients who had undergone video-assisted PVI ≥ 5 years earlier were enrolled in the present study. The institutional review board approved the research protocol, and all patients provided informed consent before surgery. We classified all the patients as having either paroxysmal AF (PAF) or non-PAF. The non-PAF group included those with persistent AF and longstanding, persistent AF. We followed the European Society of Cardiology guidelines to score the AF-related symptoms (European Heart Rhythm Association score).¹¹ Preoperative data were collected for each patient enrolled in the present study, including preoperative AF history, body mass index, and CHADS₂ score. The patient characteristics are listed in Table 1.

Preoperative Management

The patients underwent a detailed evaluation before surgery. Baseline 12-lead electrocardiographic (ECG) analysis, chest radiography, transthoracic ultrasound cardiography, transesophageal echocardiography, and computed tomography coronary artery enhancement scanning or coronary angiographic analysis were performed on admission. Also, all the patients

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Abbreviations and Acronyms

AF	= atrial fibrillation
AFL	= atrial flutter
CI	= confidence interval
ECG	= electrocardiographic
EP	= electrophysiologic
LAA	= left atrial appendage
LAD	= left atrial diameter
LAF	= lone AF
LVDd	= left ventricular end-diastolic dimension
LVEF	= LV ejection fraction
PAF	= paroxysmal AF
PV	= pulmonary vein
PVI	= PV isolation

were required to complete a health questionnaire about their AF history, previous procedures, antiarrhythmic drug use, preoperative cerebrovascular adverse events, and so on.

Surgical Technique

We used the surgical technique we have previously reported.¹² This technique consisted of epicardial radiofrequency isolation of the bilateral pulmonary vein (PV) antrum, excision of the LAA, division of the ligament of Marshall, and electrophysiologic testing. Overall, bilateral PVI was performed using an Isolator Transcatheter Endo Ablation Clamp (AtriCure, West Chester, Ohio) and the Wolf Lumitip Dissector (AtriCure). LAA removal was performed using the EZ-45 Endostapler (Johnson & Johnson Medical, Inc, Arlington, Tex). The ligament of Marshall was cut under direct vision. Intraoperative electrophysiologic testing was performed using 2 types of sensing and pacing devices (Detect and Carelink 2090 programmer, Medtronic, Minneapolis, Minn). The procedure was performed using a 10-mm, 30° thoracoscope.

Electrophysiologic Testing

Intraoperative electrophysiologic (EP) testing was performed in the latest 30 consecutive patients (15 with PAF and 15 with persistent AF). EP testing included the bilateral PV antrum and baseline and postisolation sensing and pacing. A baseline positive sensing result (rapid and disorderly atrial potentials) in the PV antrum area could be detected before PVI, and a negative sensing result (no atrial potentials) could be detected in the same area after PVI, which is termed an “entrance block.” A positive baseline pacing result was defined as obtaining atrial and ventricular capture. “Capture” has been defined as the contraction of the atrium and ventricle in response to the electrical stimulus sent from the temporary pacemaker. A negative postablation pacing result would indicate that no capture was obtained in the same area after ablation. A combined positive baseline pacing and negative postablation pacing result has been termed “exit block.” Achieving both entrance and exit block has been regarded as a transmural lesion blocking conduction in the PV antrum area.

Postoperative Management

We have recommended that patients take amiodarone in small doses for 3 months postoperatively, with the medicine tapered off in the presence of a stable sinus rhythm. A β -receptor blocking drug was used for patients intolerant to amiodarone. We have recommended that patients take a vitamin K

antagonist for postoperative anticoagulation in the initial 3-month postoperative period. The international normalized ratio was required to be 2.0 to 3.0. After 3 months, the patients with AF recurrence or a CHADS₂ score >2 points with NSR were recommended to take aspirin for anticoagulation. During the follow-up period, direct-current cardioversion was recommended if the ECG analysis showed AF recurrence. Recurrent AF was defined as AF, atrial flutter (AFL), or atrial tachycardia (AT) sustained for ≥ 30 seconds and occurring out of the postablation blanking period.^{13,14}

Follow-up

Regular follow-up visits were scheduled at 3 and 6 months postoperatively and every year after discharge. At each visit, we offered the patients free physical examinations, 12-lead ECG examinations, and 24- or 48-hour Holter monitoring (Del Mar Reynolds Medical, Inc, Irvine, Calif). During the follow-up period, the primary endpoint was defined as the absence of AF and any atrial arrhythmia recurrence. In the present study, 63 of the 91 patients (69.2%) lived outside of Beijing. It was difficult for these patients to come to our center for each examination. We advised those who could not come to our center to undergo the ECG and echocardiographic examinations in their local city and to mail the results to us. If the patients developed a relapse during the follow-up period, we enquired and recorded the details of the recurrence.

Statistical Analysis

The patient characteristics and continuous variable data are presented as the mean $\pm$ standard deviation or simple frequencies and percentages. The outcomes of the rhythms were descriptively analyzed at the follow-up intervals. Also, according to the presence of postoperative AF recurrence during the follow-up period, the patients were classified into 2 groups (nonrecurrence and recurrence). The AF-related risk factors for recurrence between these 2 groups included gender, age, AF type, AF duration, left ventricular end-diastolic dimension (LVDd), LV ejection fraction (LVEF), left atrial diameter (LAD), and body mass index. These were included in the univariate analysis using the *t* test or χ^2 test, according to the data type. Risk factors with $P < .1$ on univariate analysis were considered significant to avoid missing more possibly meaningful variables and to relax the variable selection criteria. Receiver operating characteristic curves were used to determine the cutoff value for the continuous variables that were statistically significant on univariate analysis. These continuous variables were classified into dummy variables according to their cutoff value, and their statistically significant differences in each group were tested in Kaplan-Meier curves. The Cox proportional hazards model was used to assess the risk factors (the dummy variables and the statistically significant categorical variables on univariate analysis). The forward stepwise selection procedure was used. Statistical analyses were performed using the Statistical Package for Social Sciences, version 20.0 (SPSS, Chicago, Ill).

RESULTS

Operative Results, Complications, and Mortality

The mean ablation time was 2.5 hours (range, 2.0–5.5). Of the 91 patients, 75 (82.4%) were in normal sinus rhythm (NSR) after surgery. Before ablation, 1 patient (1.1%) underwent permanent pacemaker implantation because of bradyarrhythmia and slow ventricular conduction. Also, 2 patients (2.2%) were found to have an unidentified smoke shadow located in the LAA base on the transesophageal echocardiogram preoperatively. To confirm the transesophageal echocardiographic results, the 2 patients underwent computed tomography. The computed tomography results showed the smoke shadow was in a nonenhanced area

TABLE 1. Baseline patient characteristics before ablation

Characteristic	Results
Gender	
Male	58
Female	33
Age (y)	58.0 ± 9.8
AF type	
PAF	48 (52.7)
Non-PAF	43 (47.3)
AF duration (mo)	70.4 ± 58.8
Preoperative AAD use	
β-Blocker	58 (63.7)
Amiodarone	50 (54.9)
Digoxin	20 (22.0)
LVEF* (%)	63.0 ± 9.2
LVDd* (mm)	48.1 ± 5.4
LAD† (mm)	49.4 ± 11.0
BMI (kg/m ²)	25.8 ± 5.6
Hypertension	32 (35.2)
Diabetes mellitus	4 (4.4)
Alcoholic history	14 (15.4)
Smoke history	17 (18.7)
Embolic events before ablation	7 (7.7)
Hyperthyroid	2 (2.2)
Preoperative permanent pacemaker implantation	1 (1.1)
Previous failed CA	2 (2.2)
LAA thrombus	2 (2.2)
NYHA class I-II	64 (70.3)
EHRA score III-IV	44 (48.4)
CHADS ₂ score <2	61 (67.0)

Data presented as mean ± standard deviation or n (%). AF, Atrial fibrillation; PAF, paroxysmal AF; AAD, antiarrhythmic drug; LVEF, left ventricular ejection fraction; LVDd, left ventricular end-diastolic dimension; LAD, left atrial diameter; BMI, body mass index; CA, catheter ablation; LAA, left atrial appendage; NYHA, New York Heart Association; EHRA, European Heart Rhythm Association. *Data were collected for 87 patients. †LAD was measured in the parasternal long axis, indicating the left atrial anteroposterior diameter.

with a well-defined margin in the LAA. The distance between the nonenhanced area to the orifice of LAA was >1 cm. Because of concerns regarding safety, both patients underwent LAA removal before ablation. Neither patient developed LAA thrombus after LAA excision, and neither developed thromboembolic events after surgery. One patient (1.1%) underwent conversion to median sternotomy because of bleeding during right inferior pulmonary vein dissection, early in our experience with this procedure. EP testing was successfully performed in the latest 30 patients, and all 30 patients achieved both entrance and exit block. One patient (1.1%) developed acute cardiac dysfunction caused by subendocardial infarction and recovered within 12 days. No patient died in the perioperative period. The mean ventilator support time was 12.9 ± 6.4 hours. The mean hospitalization was 15.9 ± 9.2 days. The mean follow-up duration was 60.1 ± 15.8 months. During the follow-up period, 21 patients (23.1%) received direct current cardioversion, 2 of them (2.2%) twice. At the latest follow-up point, no patient required a vitamin K antagonist

for anticoagulation. Of the 78 patients followed up for ≥5 years, 38 (48.7%) with AF recurrence (46.2%, 36 of 78) or a CHADS₂ score >2 points with NSR (2.6%, 2 of 78) received aspirin therapy to prevent cerebrovascular events. One patient (1.1%) experienced a postoperative stroke in 3 months after discharge (CHADS₂ score, 5). Four patients died of noncardiac disease during later follow-up.

Rhythm Results

During the 5-year period, 9 patients (9.9%) had changed their telephone number and home address and thus could not be contacted. In the present study, 63 of 91 patients (69.2%) did not live in Beijing. It was difficult for the patients who lived at a distance to come and stay in Beijing for several days to undergo Holter monitoring. We suggested that all patients undergo 12-lead ECG examinations at our center at each follow-up interval. Patients with AF or any other arrhythmia on 12-lead ECG analysis were not asked to undergo Holter analysis again. The Holter monitors were only used for the patients with normal 12-lead ECG findings. In all, 592 interviews were completed during the follow-up period, and 445 Holter monitoring results were recorded. The Holter monitor recording rate was 75.2% per patient.

At discharge, 66 of the 91 patients (72.5%) were in NSR, 21 (23.1%) were in AF, and 4 (4.4%) were AFL/AT. At the 3-month interval, 72 of the 91 patients (79.1%) were in NSR. The proportion of patients in NSR was 85.4% (41 of 48) in those with PAF and 72.1% (31 of 43) in those with non-PAF. At the 6-month interval, 73 of 90 patients (81.1%) were in NSR: 44 of 47 (93.6%) with PAF and 29 of 43 (67.4%) with non-PAF. At the latest follow-up point, the data were complete for 78 patients, and 43 (55.1%) were in NSR: 27 of 39 (69.2%) with PAF and 16 of 39 (41.0%) with non-PAF. Overall, 40 of the 78 patients (51.3%) were in sinus rhythm and not taking any antiarrhythmic drugs at 5 years postoperatively. In the present study, no significant difference was found in the proportion of patients in NSR between those who had undergone EP testing and those who had not (63.3% vs 55.7%, $P = .7$).

The outcomes of the rhythms were descriptively analyzed at each interval during the 5-year follow-up period (Figure 1).

Risk Factors for Later AF Recurrence

During the follow-up period, the primary endpoint was the success rate of video-assisted PVI, defined as the absence of any atrial arrhythmia recurrence lasting >30 seconds at the clinical visit and at ECG analysis or on the long-term cardiac rhythm recording after discharge. We classified all 91 patients into 2 groups according to the occurrence of the primary endpoint events. The independent risk factors for AF recurrence in these 2 groups were compared (Table 2). The results showed that 6 risk factors

FIGURE 1. General review of heart rhythm at each postoperative period. AFL/AT, Atrial flutter/atrial tachycardia; AF, atrial fibrillation; NSR, normal sinus rhythm; AADs, antiarrhythmic drugs; N., number.

had a *P* value of <.1, including gender, non-PAF, AF duration, LVDd, LVEF, and LAD.

From the receiver operating characteristic curve analysis, the preoperative LVEF, LAD, AF duration, and LVDd were predictive of postoperative AF/AFL/AT recurrence (Figure 2). The cutoff point for the LVEF was 64.5%, with a sensitivity of 61.5% and specificity of 65.7%. The area under the curve was estimated to be 0.69 (95% confidence interval [CI] 0.57-0.80; *P* = .003). The optimal cutoff point for the LAD was 44 mm, with a sensitivity of 92.1% and specificity of 52.8%. The area under the curve was estimated to be 0.77 (95% CI, 0.68-0.86; *P* < .001). The cutoff point for preoperative AF duration was 31.5 months, with a sensitivity of 84.2% and specificity of 60.4%. The area under the curve was estimated to be 0.73 (95% CI, 0.63-0.83; *P* < .001). The cutoff point for the LVDd was 45.7 mm, with a sensitivity of 83.3% and specificity of 42.3% for predicting postoperative AF/AFL/AT recurrence. The area under the curve was estimated to be 0.62 (95% CI, 0.50-0.74; *P* = .062).

TABLE 2. Comparison of AF-related risk factors stratified by primary endpoint

Factor	Primary endpoint reached		P value
	Yes (n = 53)	No (n = 38)	
Male gender	30 (56.6)	28 (73.7)	.095
Age (y)	58.4 ± 8.9	57.5 ± 10.9	.684
Non-PAF	19 (35.8)	24 (63.2)	.010
AF duration (mo)	44.7 ± 49.3	74.0 ± 52.5	.008
LVDd (mm)	47.1 ± 4.9	49.5 ± 5.9	.043
LVEF (%)	65.5 ± 8.4	59.5 ± 9.3	.002
LAD (mm)	44.9 ± 10.1	55.6 ± 9.2	<.001
BMI (kg/m ²)	25.0 ± 3.4	26.8 ± 7.7	.119
EP testing performed	11 (20.8)	19 (50.0)	.490

Data presented as n (%) or mean ± standard deviation. PAF, Paroxysmal atrial fibrillation; LVDd, left ventricular end-diastolic dimension; LVEF, left ventricular ejection fraction; LAD, left atrial dimension; BMI, body mass index; EP, electrophysiologic.

We divided all the patients into 2 groups according to the cutoff points for the 4 risk factors and compared the percentage with postoperative NSR using Kaplan-Meier analysis (Figure 3). Statistically significant differences were found in each group. We found that a preoperative LVEF of ≤64.5%, LAD of ≥44 mm, AF duration of ≥31.5 months, LVDd of ≥45.7 mm, and the presence of non-PAF were independent risk factors in our study.

We included these 5 variables in the Cox proportional hazards model. The primary endpoint was AF recurrence, and 38 patients experienced the primary endpoint. The results showed that an LAD of ≥44 mm (hazard ratio, 5.56; 95% CI, 1.68-18.387; *P* = .005), AF duration of ≥31.5 months (hazard ratio, 3.67; 95% CI, 1.50-8.95; *P* = .004) were identified as independent risk factors on multivariate analysis (Table 3).

DISCUSSION

The initial onset of AF could be related to the mostly ectopic triggers limited to the PVs.¹⁵⁻¹⁷ However, as the AF duration increases, the AF mechanisms could involve the interaction of many factors. It has been well recognized that the main factors that participate in the formation and maintenance of AF include triggers limited to the PV, right atrial trigger, autonomic ganglia plexus, and the reentry cycle on the posterior wall of the left atrium.¹⁴ Thus, video-assisted PVI alone will not be suitable for all patients with AF.

Although our long-term results have shown that the cure rate of minimally invasive PVI alone has been relatively low, it was still greater than the long-term results of single catheter ablation, as recently reported. It was reported by Sorgente and colleagues¹⁸ that the cure rate for single catheter ablation was only 23% at 6 years of follow-up. Also, for all the cases, the cure rate for paroxysmal AF was 36% and for persistent AF was only 15%.¹⁸ Catheter ablation has been limited by its complications, such as PV stenosis, thrombosis, and pericardial tamponade. It also has the disadvantages of a long “learning curve” and poor repeatability. Catheter ablation not only carries a high risk of reoperation, but also increases patients’ economic and psychological burden. It has also been demonstrated in a recent double-center randomized clinical study of catheter ablation and minimally invasive surgical ablation of atrial fibrillation that the overall cure rate for catheter ablation was obviously lower than that of minimally invasive surgical ablation during the same period (36.5% vs 65.6%, *P* = .0022).¹⁹ Minimally invasive PVI has shown more advantages than catheter ablation in some respects.

In the American Heart Association/European Society of Cardiology AF management guidelines, AF has been classified into PAF, persistent AF, and longstanding, persistent AF according to the preoperative duration of AF.^{11,20} At present, the preoperative AF type has been accepted as an essential index of whether the patient is suitable for

ACD

FIGURE 2. Receiver operating characteristics curve showing the cutoff value for preoperative (A) left ventricular ejection fraction (LVEF), B, left atrial diameter (LAD), C, atrial fibrillation (AF) history, and D, left ventricular end-diastolic dimension (LVDd) for atrial fibrillation/atrial flutter/atrial tachycardia recurrence after video-assisted pulmonary vein isolation alone. AUC, Area under the curve.

video-assisted PVI alone. It has been previously reported that the postoperative NSR rate of PVI alone was greater for PAF, with a significantly lower NSR rate for persistent AF.^{8,21,22} In our study, the average LAD was 49.4 ± 11.0 mm. At 5 years of follow-up, the general NSR rate was 55.1% (43 of 78). The NSR rate for those with PAF and non-PAF was 69.2% and 41.0%, respectively ($P = .01$). Our results have also shown that the long-term NSR rate for those with PAF postoperatively was greater than that for the non-PAF. As recently reported, using the Dallas lesion and five-box lesion to add ablation lines on the basis of PVI improved the NSR rate in those with persistent AF in the early follow-up period.²³⁻²⁵ This might have resulted from preventing the macroreentry from propagating by adding ablation lines.²⁶ The additional ablation lesions were created for patients with LAF and a large preoperative LAD and long AF duration later in our study period. The initial results from our center showed that the cure rate for this novel procedure for non-PAF was 75.0% at 1 year of follow-up. Our results have also demonstrated that PVI alone might not be sufficient for persistent AF.

However, the question remains whether all patients with PAF are suitable for video-assisted PVI alone and whether

all patients with persistent AF are not suitable for video-assisted PVI alone. In some studies, the risk factors that could affect the postablation recurrence of AF also included the preoperative LAD, ablation device, and energy selection.²⁷⁻³⁰ The results of our study showed that a preoperative AF duration of ≥ 31.5 months was another independent risk factor for AF recurrence. A total of 53 patients had an AF duration of ≥ 31.5 months (47.2% with PAF and 52.8% with non-PAF) and 38 had an AF duration of < 31.5 months (60.5% with PAF and 39.5% with non-PAF). Our results have shown that the NSR of patients with an AF duration of ≥ 31.5 months was significantly lower than that of patients with an AF duration of < 31.5 months (39.6% vs 84.2%; $P < .001$). When we included the preoperative AF type, AF duration of ≥ 31.5 months, non-PAF, and preoperative LVDd, LVEF, and LAD in the Cox proportional hazards model, a preoperative AF duration of ≥ 31.5 months and LAD were statistically significant, with the LAD the most essential risk factor (hazard ratio, 5.56; 95% CI, 1.68-18.387; $P = .005$). This might indicate that the preoperative LAD is more sensitive than the preoperative AF duration for predicting the recurrence of AF postoperatively. In addition, the average LAD of the patients

FIGURE 3. Kaplan-Meier postoperative atrial fibrillation (AF)-free survival between the patients with preoperative (A) left ventricular ejection fraction (LVEF) of <64.5% versus ≥64.5% ($P = .015$); B, left atrial diameter (LAD) of <44 mm versus ≥44 mm ($P < .001$); C, atrial fibrillation duration of <31.5 months versus ≥31.5 months ($P < .001$); and D, left ventricular end-diastolic dimension (LVDd) of <45.7 mm versus ≥45.7 mm ($P = .013$).

with AF and an AF duration of ≥31.5 months versus an AF duration of <31.5 months was 52.8 ± 10.9 mm and 44.6 ± 9.4 mm ($P < .001$), respectively. This finding could also have demonstrated that as the duration of AF increases, the left atrium expands and affects the postoperative recurrence of AF. These findings could also have resulted because as the hemodynamics change (greater atrial pressure and wall stress), the structural remodeling would be worse (fibrosis, dilatation, and hypertrophy) in the left atrium,³¹ which could

lead to the facilitation of AF recurrence. As recently reported, the occurrence of postoperative AFL/AT was mainly related to reentry around the ablation lines in the PVs, posterior wall of the left atrium, and isthmus.³²

Our study had several limitations. The small sample size in our study might have limited the generalizability and caused the wide range of CIs for the LAD in the multivariate model. In the early stage of beginning this technique in our clinic center, we lacked the device and technology for EP testing; thus, two thirds of patients did not undergo EP testing. Also, most of our patients did not live in Beijing, and it was difficult for them to come and stay in Beijing for several days to undergo Holter monitoring. We suggested that all patients undergo 12-lead ECG examinations at our center at each follow-up interval. The patients who were in AF or had any other arrhythmia by the 12-lead ECG analysis were not recommended to undergo Holter

TABLE 3. Hazard ratios for recurrence in Cox proportional hazards model

Factor	HR	95% CI	P value
LAD ≥44 mm	5.56	1.68-18.39	.005
AF duration ≥31.5 mo	3.67	1.50-8.95	.004

HR, Hazard ratio; CI, confidence interval; LAD, left atrial diameter; AF, atrial fibrillation.

analysis again. The Holter monitors were used only for those patients with normal 12-lead ECG findings. Thus, our Holter monitoring results could not reflect the true situation. As a retrospective study, our study also was limited by the lack of a comparison with catheter ablation or other surgical energy sources and technologies.

CONCLUSIONS

Our research has shown that the postoperative NSR rate after video-assisted PVI alone would be low for patients with AF and a larger LAD and long AF duration. The LAD was the most important factor determining long-term postoperative recurrence. In addition, for the patients with a longer AF duration, the rate of recurrence was greater, and video-assisted PVI alone should not be recommended for those patients. In contrast, video-assisted PVI alone could be considered for patients with a shorter AF duration and a normal LAD. At present, we have performed 332 minimally invasive surgeries in our center. Additional ablation lesions were created for the patients with LAF and a large preoperative LAD and long AF duration in our later study. The later results will be verified as our study continues.

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