Pulmonary vein isolation and autonomic denervation for the management of paroxysmal atrial fibrillation by a minimally invasive surgical approach

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Background: Advances in technology such as epicardial bipolar radiofrequency pulmonary vein isolation, ganglionated plexi identification, and isolation and thoracoscopic left atrial appendage exclusion have enabled less invasive surgical options for management of atrial fibrillation.

Methods: We performed a prospective, nonrandomized study of consecutive patients with symptomatic paroxysmal atrial fibrillation undergoing a video-assisted, minimally invasive surgical ablation procedure. The procedure consisted of bilateral, epicardial pulmonary vein isolation with bipolar radiofrequency, partial autonomic denervation, and selective excision of the left atrial appendage. Minimum follow-up was 1 year with long-term monitoring (24-hour continuous, 14-day event or pacemaker interrogation).

Results: Between March 2005 and January 2008, 52 patients (35 male), mean age 60.3 years (range, 42–79 years) underwent the procedure. The left atrial appendage was isolated in 88.0% (44/50). Average hospital stay was 5.2 days (range 3–10 days). There were no operative deaths or major adverse cardiac events. On long-term monitoring, freedom from atrial fibrillation/flutter/tachycardia was 86.3% (44/51) and 80.8% (42/52) at 6 and 12 months, respectively. Antiarrhythmic drugs were stopped in 33 of 37 patients and warfarin in 30 of 37 of the patients in whom ablation was successful at 12 months. Freedom from symptoms attributed to atrial fibrillation/flutter/tachycardia was 78.0% (39/50) at 6 months and 63.8% (30/47) at 12 months.

Conclusions: Minimally invasive surgical ablation is effective in the management of paroxysmal atrial fibrillation as evidenced by freedom from atrial arrythmias by long-term monitoring at 12 months. Measuring success using clinical symptoms underestimated clinical success as compared with long-term monitoring. (J Thorac Cardiovasc Surg 2010;140:823-8)

Atrial fibrillation (AF) is a superventricular tachyarrhythmia characterized by uncoordinated atrial activation and consequent deterioration of mechanical function.[1] With an estimated prevalence of 0.4% to 1% in the general population, AF is the most common cardiac arrhythmia encountered in clinical practice.[2] AF is associated with an increased long-term risk of stroke, heart failure, and all-cause mortality.[3] Clinical symptoms associated with AF are quite variable in character and severity but are generally manifested as decreased energy level, dyspnea, and palpitations. Objectives for the management of AF are threefold: rate control, prevention of thromboembolism, and correction of the rhythm abnormality. So that these objectives can be achieved, most patients are managed with antiarrhythmic drugs (AADs) and anticoagulation to minimize the embolic and hemodynamic sequelae of the condition.[1]

Haissaguerre and associates[4] initially described spontaneous initiation of AF by ectopic beats originating in the pulmonary veins. This led to the development of catheter-based treatment strategies with the goal of electrical isolation of the pulmonary veins.[5] This technique was hampered by the technical difficulty of achieving transmural electrical isolation using endocardial catheter ablation. The feasibility of pulmonary vein isolation by a minimally invasive surgical approach was initially described by Wolf and associates.[6] This procedure evolved into an epicardial bipolar radiofrequency ablation that includes isolation of the pulmonary vein antrum, detection and ablation of ganglionated plexi (GP), division of the ligament of Marshall, and removal of the left atrial appendage (LAA).

The importance of the autonomic nervous system in the initiation of AF was first described by Coumel[7-9] in 1993. GPs, found in atrial fat pads, have subsequently been shown to play a role in initiation and maintenance of AF.[10,11] Moreover, the ablation of these GPs has been demonstrated to abolish vagally mediated AF.[12]

In addition to the GP, the ligament of Marshall has been shown to contain sympathetic and parasympathetic nerve

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Abbreviations and Acronyms
AADs = antiarrhythmic drugs
AF = atrial fibrillation
GP = ganglionated (ganglionic) plexi
LAA = left atrial appendage
LTM = long-term monitoring

trunks important to cardiac autonomic function. Moreover, patients with a well-developed ligament of Marshall have been found to have an increased incidence of arrythmogenic foci in the left superior pulmonary veins.[13]

Finally, to further enhance effectiveness in preventing thromboembolism, exclusion or removal of the LAA is optimal. This is critical because thrombus material associated with AF arises most commonly in the LAA. Decreased flow within the LAA during AF (as evidenced by the formation of spontaneous echo contrast or ''smoke'') has also been associated with embolic events.[14]

Herein, we describe our initial experience and outcomes with a minimally invasive surgical procedure of pulmonary vein isolation by bipolar radiofrequency, intraoperative confirmation of transmurality, mapping for and ablation of GPs, and exclusion of the LAA.

METHODS

A nonrandomized series of consecutive patients with symptomatic paroxysmal AF were entered into the study. The study was approved by the Institutional Review Boards of Medical City Hospital, Dallas, Texas, and Baylor University Hospital, Dallas, Texas, and informed consent was obtained from all patients. All definitions and reporting standards were in accordance with the 2007 Heart Rhythm Society (HRS)/European Heart Rhythm Association (EHRA)/European Cardiac Arrhythmia Society (ECAS) expert consensus statement for catheter and surgical ablation of AF.[15]

Surgical Procedure

Surgery was performed with the patient under general anesthetia with double-lumen endotracheal intubation for selective pulmonary ventilation. Arterial blood pressure and pulmonary artery monitoring by a Swan–Ganz catheter (Edwards LifeSciences, Irvine, Calif) was performed in all patients. Transesophageal echocardiography was performed on the operating table before and during each procedure. In addition, patients with prior catheter ablations underwent computed tomography or magnetic resonance imaging of the left atrium before the procedure. The procedures were performed through bilateral 5-cm anterior minithoracotomies in the third or fourth intercostal space. Video assistance with a 5-mm 30° endoscope was used. A sensing device was used to detect atrial electrical activity conducted into the upper and lower right pulmonary veins and the bifurcation. High-frequency stimulation at 12 volts at a cycle length of 50 ms and a pulse width of 1 to 10 ms was used to map 13 areas for GPs (Figure 1). These locations were recorded for subsequent ablation. Detection and localization of GPs were determined by evidence of a vagal response as defined by an increase in the RR interval of greater than 50% from baseline. Circumferential dissection of the right pulmonary veins with a lighted dissector was then performed. A bipolar radiofrequency clamp (Atricure, Inc, Cincinnati, Ohio) was then guided around the veins. The bipolar radiofrequency clamp was then used to perform wide antrum circumferential ablation. The ablation energy was delivered 3 to 5 times. Entrance block was confirmed by sensing for atrial activity in the pulmonary veins. If atrial activity was detected, ablation was readministered until entrance block was confirmed. Any of the 13 GP areas that still showed evidence of vagal innervation after application of the ablation lines were then targeted for direct radiofrequency ablation using a monopolar pen. On completion, a small-caliber surgical drain was placed through the thoracoscopic site. The patient was then repositioned for optimal access to the left side. Mirror-image surgical incisions were made. Whereas the pericardium was opened anterior to the phrenic nerve on the right side, it was opened posterior to the phrenic nerve on the left side. The same sequence of pulmonary vein sensing for the detection of atrial activity was performed first, followed by high-frequency stimulation for detection of GPs, especially in the area of the ligament of Marshall. Areas that showed evidence of vagal autonomic innervation were recorded on a map that outlined 10 areas on the left side (Figure 2). The ligament of Marshall was then divided and the pulmonary veins encircled as on the right side. A bipolar radiofrequency clamp was then applied to perform wide antrum circumferential ablation. On confirmation of pulmonary vein entrance block and targeted autonomic denervation, a drain was placed on the left side.

After completion of the left-sided ablation, excision or exclusion of the LAA was performed selectively. A variety of techniques were used to exclude the appendage, including excision with an endoscopic stapler with or without bovine pericardial support or simply staple exclusion of the LAA. In cases in which it was deemed hazardous to perform the appendectomy owing to anatomic constraints, the appendage was left intact. For all patients having LAA exclusion, transesophageal echocardiography was used to confirm that the exclusion was successful. If AF was present at the end of the procedure, the patient was cardioverted to sinus rhythm. The general anesthetic was reversed and the patient was extubated in the operating room. The patient was monitored for the first 24 hours in the intensive care unit.

Postoperatively, patients were returned to the same antiarrhythmic drug regimen that they were using when seen preoperatively. This was restarted as soon as they were able to resume receiving oral medication and was continued for the first 30 to 90 days.

Follow-up

Continuous telemetric monitoring was performed throughout the hospital stay and a 12-lead electrocardiogram was obtained 1, 3, 6, and 12 months after discharge. Long-term monitoring (LTM) by either a 24-hour Holter monitor, 2- to 3-week event monitoring, or interrogation of an implanted pacemaker was obtained at 6 and 12 months. The definition of success for the procedure was no episodes of AF/left atrial flutter/atrial tachycardia greater than 30 seconds. Patients were interviewed to determine resolution or persistence of symptoms related to AF. Patient data were recorded concurrently into a custom-computerized database. All patients were monitored by a dedicated AF nurse specialist and the operating surgeon and electrophysiologist. Preliminary 6-month data for a subset of these patients have been published previously.[16]

RESULTS

From March 2005 through January 2008, 52 patients with paroxysmal AF underwent the described ablation procedure. Patient demographics are listed in Table 1. All procedures were completed as planned with no mortality or major complications. The LAA was excised or stapled in 44 (88.0%) of 50 patients. LAA exclusion was not performed if the operative surgeon deemed the LAA anatomy unsafe for endoscopic staple exclusion. There were no instances of significant postoperative bleeding, heart block, or phrenic

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