HOSPITAL CHRONICLES 2012, VOLUME 7, SUPPLEMENT 1: 154–156

HOW TO SESSION: TECHNIQUES & PRACTICE

Atrial Fibrillation Ablation Technique: State of the Art

Michalis Efremidis, MD, Luiza Lioni, MD

2nd Department of Cardiology, "Evagelismos" General Hospital, Athens Greece

ABSTRACT

The role of the pulmonary veins in the initiation of atrial fibrillation has clearly been elucidated and has led to catheter ablation of atrial fibrillation (AF) via pulmonary vein isolation, currently achieved with use of radiofrequency energy. The 2011 American guideline update on the management of AF considers catheter ablation as a Class Ia indication in patients without significant structural heart disease refractory to antiarrhythmic drug therapy. The 2011 update on the guidelines for the management of AF by the European Society of Cardiology lists catheter ablation as a class IIa recommendation in patients refractory to antiarrhythmic drug therapy. Catheter ablation may be considered first-line therapy in a select group of patients with paroxysmal AF and no significant underlying structural heart disease if an experienced operator performs the procedure (class IIb indication). It should be kept in mind that the single-procedure success rate is low, with only 40%, 37% and 29% of patients remaining free from recurrent arrhythmias at 1, 2 and 5 years of follow-up, respectively; the success rates increase after two procedures to 87%, 81% and 63% at 1, 2 and 5 years. Patients with longstanding persistent AF have lower success rates compared with patients with paroxysmal or persistent AF. This article focuses on recent developments and new technologies currently under investigation.

KEY WORDS: *atrial fibrillation; radiofrequency catheter ablation; pulmonary vein isolation*

Since the first report on the role of the pulmonary veins in the initiation of atrial fibrillation (AF), catheter ablation of AF effected via pulmonary vein isolation (PVI) has undergone major evolutions.[1] This article will focus on recent developments and new technologies currently under investigation.

Abbreviations
AF = atrial fibrillation
CFAE = complex fractionated atrial electrograms
MRI = magnetic resonance imaging
PVI = pulmonary vein isolation

GUIDELINES FOR THE TREATMENT OF ATRIAL FIBRILLATION

The 2011 American College of Cardiology Foundation/American Heart Association/Heart Rhythm Society focused update on the management of AF considers catheter ablation as a Class IA indication in patients without significant structural heart disease refractory to antiarrhythmic drug therapy.[2] By contrast, the 2011 update on the guidelines for the management of AF by the European Society of Cardiology lists catheter ablation as a class IIa recommendation in patients refractory to antiarrhythmic drug therapy.[3] Catheter ablation may be considered first-line therapy in a select group

Address correspondence to:
Michalis Efremidis, MD, Evagelismos Hospital, Athens, Greece;
e-mail: micbcar@otenet.gr

Conflict of Interest: none declared

of patients with paroxysmal AF and no significant underlying structural heart disease if an experienced operator performs the procedure (class IIb indication).

RADIOFREQUENCY CATHETER ABLATION

Recently, data on 5-year follow-up results became available reporting on the outcome of patients undergoing ablation for paroxysmal and persistent or longstanding persistent AF. Haissaguerre *et al* published their 5-year follow-up data on patients undergoing catheter ablation of AF.[4] More than a third of enrolled patients suffered from persistent or longstanding persistent AF. The fairly high number of patients with advanced AF may explain the low single-procedure success rate. After 1, 2 and 5 years of follow-up, only 40, 37 and 29% of patients were free from recurrent arrhythmias, respectively. After a median of two procedures per patient, the arrhythmia-free survival rate increased to 87, 81 and 63% at 1, 2 and 5 years. Subgroup analysis revealed that patients with longstanding persistent AF were almost twice as likely to experience arrhythmia recurrence than patients with paroxysmal or persistent AF. Hence, in view of the sobering data on the results of catheter ablation in patients in the advanced stages of the disease, a preferred strategy may be an early ablative approach to prevent transition into chronic forms of AF. Since AF results in fibrosis of the left atrium and in turn atrial fibrosis facilitates development of persistent AF, assessment of the extent of left atrial fibrosis by magnetic resonance imaging (MRI) is currently under investigation. Preprocedural analysis of the degree of atrial fibrosis may serve as a predictor for successful AF ablation. The Utah classification quantifies the extent of left atrial fibrosis (class I <5% and class IV >35% fibrosis of the left atrium), while its use was predictive of subsequent AF ablation outcome.[5] Greater extent of fibrosis correlated with a higher rate of arrhythmia recurrence.

To date, it is unclear which strategy serves best the patient with longstanding persistent AF defined as continuous AF lasting more than 12 months. Complex fractionated atrial electrograms (CFAE) are thought to play an important role in the maintenance of AF. Nademanee *et al* reported high procedural success rate when solely targeting CFAE for the treatment of AF, while a similar study by Oral *et al* could not corroborate these findings.[6] Three meta-analyses concluded that CFAE ablation provided additional benefit to PV ablation alone in patients with persistent AF. But, targeting CFAE will result in longer procedure and fluoroscopy times, as well as a higher number of energy applications with the potential for significant collateral damage.

CRYOBALLOON ABLATION

The randomized, multicenter STOP AF (Sustained Treatment of Paroxysmal Atrial Fibrillation) was designed to compare the efficacy of PVI using cryoballoon ablation with antiarrhythmic drug therapy. Following 245 patients for 1 year, nearly 70% in the ablation arm were free from recurrent AF without the use of antiarrhythmic medication. This compared favorably to the medication-only group with 7.3% of patients still in sinus rhythm. Several European trials have shown that cryoballoon ablation is a viable option for patients with paroxysmal or short-lasting persistent AF.[7] Right phrenic nerve palsy was the most common complication in these trials, while the STOP AF study reported a higher rate of 11.2%. Using the smaller 23-mm balloon may result in distal positioning of the balloon catheter within the right superior pulmonary vein ostium, thereby increasing the risk for inadvertent phrenic nerve palsy. This complication is minimized with the bigger 28-mm balloon allowing for a more antral position along the right superior pulmonary vein ostium.

LASER BALLOON ABLATION

An alternative technology based on the use of laser energy, the Endoscopic Ablation System (Cardiofocus, MA, USA) combines balloon technology with direct visualization of intracardiac tissue through use of an endoscopic camera. A laser beam allows point-by-point lesion creation after a compliant balloon is wedged into the pulmonary vein facilitating direct balloon-to-tissue contact. As opposed to currently available ablation systems, the novel catheter design permits direct visualization of left atrial tissue, enabling the operator for the first time to apply lesions in plain sight. Initial results in patients with paroxysmal AF are encouraging, demonstrating successful acute isolation in 99% of pulmonary veins and a 1-year success rate of 60% after a single procedure off antiarrhythmic medication.[8] The incidence of esophageal thermal lesions was similar (18 vs 16%), however, the severity of thermal lesions (ulcerations) was more pronounced in the laser balloon group.

MULTIELECTRODE ABLATION CATHETER

The decapolar pulmonary vein ablation catheter (PVAC, Medtronic Ablation Frontiers, CA, USA) facilitates duty-cycled unipolar and bipolar radiofrequency current delivery at the individual pulmonary vein ostium. The combination of unipolar and bipolar radiofrequency current facilitates deployment of complete circular lesions. In paroxysmal AF, results have been promising with 83% of treated patients free of recurrent AF over a 6-month follow-up period.[9] Two

separate studies investigated the impact of AF ablation using irrigated radiofrequency energy, the cryoballoon catheter and the multielectrode catheter on the incidence of silent cerebral embolizations. Both studies independently found a significantly higher rate of silent embolization on postprocedural MRI in those patients treated with the multielectrode catheter (37.5 and 38.9%, respectively).

CONTACT FORCE SENSING TECHNOLOGY

Using radiofrequency current, lesion formation will depend on several factors currently measured in the electrophysiology laboratory, such as catheter tip-to-tissue temperature, power and duration of energy application. While these parameters can be directly measured during radiofrequency current delivery, assessment of wall contact, that is, contact force between catheter tip and tissue, is not as straightforward. It has been shown previously that changes in impedance and electrogram amplitude correlate poorly with tissue–electrode contact. The importance of proper contact force becomes obvious when considering that insufficient contact will result in suboptimal lesion formation. In turn, excessive contact force may result in collateral tissue damage, for example, cardiac perforation or esophageal injury.

A novel contact force sensor embedded into the distal tip of a standard 7F steerable, radiofrequency ablation catheter (TactiCath, Endosense SA, Geneva, Switzerland) allows real-time assessment of contact force during energy delivery.[10]

The SmartTouch contact force catheter by Biosense Webster, Inc. uses electromechanical deformation of a spring situated at the distal tip of the catheter for assessment of local contact force. The catheter integrates seamlessly with the CARTO 3 electroanatomical mapping system.

REMOTE MAGNETIC NAVIGATION AND ABLATION

It has previously been shown that AF ablation using magnetic navigation (Stereotaxis, MO, USA) is feasible. Compared to conventional manual radiofrequency ablation, remote-controlled magnetic PVI reduces operator radiation exposure by one third.[11] This is achieved by limiting the operator's time spent alongside the patient, since mapping and ablation is performed from the control room. However, total procedure times are still longer when compared with conventional manual PVI. In order to analyze the time needed for individual procedural steps during magnetic ablation, patients were prospectively enrolled to manual or remote magnetic ablation. Preliminary findings confirm previous data in that isolation of the right inferior pulmonary vein is particularly challenging and time consuming.

In conclusion, pulmonary vein isolation (PVI) is the cornerstone of AF catheter ablation. Although long-term results in patients with paroxysmal AF are encouraging, outcome data in patients with persistent or longstanding persistent AF highlight the need for improvement. Alternative energy sources and new technologies under development may overcome current limitations in transmural lesion formation, heralding a new era in catheter ablation of AF.

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