Progress continues in the quest to cure atrial fibrillation with catheter ablation techniques

Over the past 5 years, the electrophysiology community has been focused on the development of catheter ablation techniques and ablation systems to cure atrial fibrillation. This endeavour has been fuelled by a number of factors including: (1) the clinical importance of atrial fibrillation because of its high prevalence in the general population, associated symptoms, stroke risk, and increased mortality, (2) the limited efficacy, side effects, and risks associated with pharmacological therapy, and (3) demonstration of the feasibility of curing atrial fibrillation with catheter ablation techniques.

Swartz and colleagues were the first to demonstrate that atrial fibrillation can be cured using catheter ablation techniques. These authors reported that creation of linear lesions in the right and left atrium results in a progressive increase in the organization of atrial activity until sinus rhythm is restored[1]. The placement of the lesion lines was designed to emulate those placed surgically in the Maze procedure developed by Cox et al.[2]. Long term cure of atrial fibrillation was achieved in 23 of 29 patients. Although these results demonstrated that catheter ablation of atrial fibrillation using a catheter-based Maze procedure was feasible, the extremely arduous nature of this procedure — with prolonged procedure and fluoroscopy times, the frequent need for second ablation procedures, and the development of several major complications — made it clear that this procedure was not appropriate for widespread clinical use without major advances in the technology of creating linear atrial lesions. Trials are now underway using newer catheter ablation systems designed specifically to facilitate the creation of continuous linear lesions[3].

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Almost simultaneous with Swartz’s work, Haissaguerre and colleagues began a series of investigations into the role of catheter ablation in the treatment of atrial fibrillation. An initial series of three patients who underwent successful ablation of atrial fibrillation was published in 1994[4]. In each of these patients, atrial fibrillation was determined to arise from a ‘focal source’ located near the sinus node, mid lateral right atrium, and as a result of atrial flutter. The description and successful treatment of these three patients suggested that in some patients atrial fibrillation may result from a focal trigger and that ablation of this trigger could result in cure of atrial fibrillation. Prior research in an animal model had demonstrated that atrial fibrillation could be induced by local administration of aconitine which triggered a rapid focal atrial tachycardia[5]. This type of ‘focal atrial fibrillation’ was also shown to be cured by isolation of the initial source of the focal aconitine-induced focal atrial tachycardia from the remainder of the atria.

In a subsequent report on 45 patients with frequent drug-refractory episodes of atrial fibrillation, Haissaguerre et al. found that a purely right-sided linear ablation approach was successful in 33% of patients, and that a higher success rate (60%) could be achieved with the addition of ablative lesions placed in the left atrium[6]. In addition, these investigations found that linear lesions were often arrhythmogenic due to gaps in the ablative lines, yet many patients were ultimately cured with ablation of a single rapidly firing ectopic focus. These ectopic foci were found at the orifices of the left or right superior pulmonary veins or near the superior vena cava. The latter observation led these investigators to systematically attempt cure of paroxysmal atrial fibrillation by mapping and ablating individual foci of ectopic activity, first in a series of nine patients[7], then in a series of 45[8], and most recently in a series of 90 patients[9]. Many of these foci were found well into the veins, outside of the cardiac silhouette, where myocardial bands are known to extend[10,11]. In their most recent series, the long-term success rate for curing atrial fibrillation with a focal ablation approach was 71%. The feasibility of curing paroxysmal atrial fibrillation using ‘focal ablation’ has been confirmed by Chen et al. who reported in a series of 79 patients that 86% were free of recurrent atrial fibrillation during a 6+2 month follow-up period[12,13].

The favourable results of these clinical trials have established that: (1) paroxysmal atrial fibrillation is frequently triggered from a focal source, (2)
pulmonary veins are a very important source of these focal triggers, and (3) that mapping and ablation of these triggers has the potential to cure a majority of patients with paroxysmal atrial fibrillation. Despite these encouraging results, obstacles in the strategy of targeting arrhythmogenic foci within the pulmonary veins have prevented widespread acceptance of this procedure. It was unclear, for example, which mapping strategy should be used to identify appropriate sites for ablation. Whereas some investigators would sequentially map each of the four pulmonary veins and target ectopic fblings from the pulmonary veins, others would only target ectopic fblings that actually precipitated atrial fibrillation. Others still would place catheters simultaneously in each of the four pulmonary veins in an attempt to identify arrhythmogenic foci. The induction of atrial ectopy and/or atrial fibrillation was required with each of these approaches. This proved to be an important limitation of this strategy as up to 30% of patients brought to the electrophysiology laboratory for catheter ablation procedure has insufficient atrial ectopy induced to allow accurate mapping to be performed. A second obstacle was that it was uncertain whether the appropriate end-point of this procedure was the elimination of atrial premature beats, the inability to induce atrial fibrillation, or both. And a final obstacle was the growing appreciation that pulmonary vein stenosis may occur as a complication of catheter ablation within the pulmonary veins.

The past 2 years have witnessed the development of several new anatomically based strategies for catheter ablation of paroxysmal atrial fibrillation arising from the pulmonary veins. Haissaguerre and colleagues have modified their original approach and now perform catheter ablation at the pulmonary vein ostium guided by circumferential mapping data obtained using a steerable circular multipolar catheter which is designed to fit just inside the pulmonary vein ostium. Advantages of this approach include an easily defined end-point for catheter ablation, a marked reduction in the risk of pulmonary vein stenosis due to the ostial location of the radiofrequency applications, and the intuitive value of having an electrode catheter to mark the orifice of the pulmonary vein. In a recently published series, 73% of the 70 patients had complete elimination of atrial fibrillation without antiarrhythmic therapy. Forty percent of these patients required two ablation sessions. This modified mapping strategy has been embraced by the electrophysiology community which has confirmed these results. An alternative anatomical strategy has been employed successfully by Pappone and colleagues. These investigators have reported that the creation of circumferential lesions around the pulmonary vein ostia guided by electroanatomical mapping results in elimination of atrial fibrillation in 62% of patients without the need for antiarrhythmic therapy and in an additional 23% of patients with the use of antiarrhythmic therapy. Importantly, the efficacy of this approach was similar regardless of whether the patients had paroxysmal or permanent atrial fibrillation. A third strategy involves an investigational balloon based ablation system, which is deployed within the pulmonary veins and deliver ultrasound energy to the entire circumference of the pulmonary vein. These systems are now in clinical trials. This system was successful in 66% of the initial 15 patients who underwent this procedure as part of an ongoing multicentre clinical trial.

The electrophysiology community appreciates the pioneering efforts of Cox, Swartz, Haissaguerre, and others. The 7 years which have passed since Haissaguerre and colleagues first called our attention to the concept of focal triggers of atrial fibrillation have resulted in dramatic changes in the approaches being used to treat atrial fibrillation with catheter ablation techniques. The current anatomically based ablation strategies show great merit. Although there is likely to be continued evolution in the tools we use to map and ablate focal atrial fibrillation it appears likely that these anatomically based strategies will withstand the test of time. The concept of catheter ablation of focal atrial fibrillation emerging as a first line treatment option is likely to become a reality.

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References


