Editorial

Ablation of Atrial Fibrillation: Twenty Years' Experience

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The first catheter ablation procedure in humans was performed in 1981 by the American physician Melvin Scheinman. The method has been used since then to treat countless arrhythmias that are due to arrhythmogenic foci, or specific pathways or bundles. However, only during the last 20 years has catheter ablation therapy been used to treat more complex arrhythmias, such as atrial fibrillation.

The success of the Maze surgical procedure for atrial fibrillation led scientists to imitate it using a catheter that delivers radiofrequency energy. The first attempts were made in 1994, by Schwartz in the left atrium and Haïssaguerre in the right atrium. The creation of linear lesions in the left atrium in patients with chronic atrial fibrillation resulted in 78% of them remaining in sinus rhythm over a 12-month follow-up period; however, the procedure took a rather long time and in 39% of patients a repeat procedure was necessary.

Taking into consideration the potential risks of access to the left atrium, Haïssaguerre applied the ablation method to the right atrium without particular success. One year after the creation of complex linear lesions in the right atrium of patients with paroxysmal atrial fibrillation, Haïssaguerre et al reported maintenance of sinus rhythm in 33% of cases. However, in unselected patients with atrial fibrillation ablation of the right atrium had disappointing results.

The goal of catheter ablation was to create linear lesions that would modify the atrial fibrillation substrate, until a milestone study by Haïssaguerre in 1998.[1] This study demonstrated that triggers in the pulmonary veins caused paroxysmal atrial fibrillation and that radiofrequency ablation of these foci led to inhibition of the arrhythmia. Thus, by mapping and ablating these triggers within the pulmonary veins, Haïssaguerre managed to control the arrhythmia in a significant number of patients, establishing catheter ablation as a therapeutic approach in atrial fibrillation.

Consequently, the interest of electrophysiologists turned from linear lesions to the ablation of ectopic foci in the pulmonary veins. However, the difficulty of locating these foci and the high relapse rate limited the method's application. Furthermore, pulmonary vein stenosis was a common complication that had high morbidity.

The need to create linear lesions peripheral to the pulmonary veins and attempts to limit the complications and improve the effectiveness of the initial ablation methods for atrial fibrillation led Pappone to introduce an innovative method that could be used in the treatment of atrial fibrillation.[2] Electroanatomical mapping and three-dimensional imaging of the atria—especially the left—not only were superior to fluoroscopic imaging, but also gave additional impetus to the therapeutic strategy for atrial fibrillation, contributing to both the safety and the effectiveness of ablation.

Using this new electroanatomical mapping system, Pappone and his group introduced a new ablation method that included the creation of circular lesions around the ostium of each of the pulmonary veins and one additional linear lesion in the mitral isthmus.[3] After one year's follow-up, 85% of patients with paroxysmal or persistent atrial fibrillation remained in sinus rhythm, with a significant proportion (62%) having no need of antiarrhythmic medication.

During the same period, Haïssaguerre and his group pioneered the use of a circular mapping catheter, which allowed lesions to be targeted at sites in the pulmonary veins that showed early electrical potentials.[4] Using the same catheter, the complete electrical isolation of all four pulmonary veins could be confirmed.

The combination of three-dimensional electroanatomical mapping, circular ablation, and the use of a circular mapping catheter is now found in most electrophysiological laboratories, with the final goal being the electrical isolation of all four pulmonary veins.

A number of studies have also underlined the important role of ectopic foci at sites apart from the pulmonary veins, which promote the occurrence of paroxysmal atrial fibrillation. Such ectopic foci may be observed in the superior *vena cava*, the posterior free wall of the left atrium, the *crista terminalis*, the entrance to the coronary sinus, the ligament of Marshall, and the interatrial septum. The application of radiofrequency energy in these regions is effective and safe for the treatment of arrhythmia.

Although electrical isolation of the pulmonary veins, and hence the elimination of ectopic foci, has good results for paroxysmal atrial fibrillation, it is not sufficient for more persistent forms of the arrhythmia, where the substrate starts to play an important role. In fact, in the vast majority of cases of persistent atrial fibrillation, the irreversible electrical and mechanical remodelling of the atrial substrate is held responsible for the perpetuation of the arrhythmia. In these patients, in addition to the electrical isolation of the pulmonary veins, further modification of the substrate is required in order to successfully treat the atrial fibrillation. Examples of such therapeutic procedures are ablation of the parasympathetic nerves and ablation of complex fractionated atrial electrograms.

During the last decade, attempts at catheter treatment of atrial fibrillation have been directed towards cardiac sympathetic denervation. The four main nerve ganglia are located in epicardial fat layers on the boundary of the pulmonary vein antrum. The first large study to investigate the effectiveness of denervation of the pulmonary veins in patients with paroxysmal atrial fibrillation was published by Pappone in 2004. The study showed that supplementary sympathetic denervation during circular pulmonary vein ablation significantly reduced the recurrence of the arrhythmia. In fact, cardiac sympathetic denervation in combination with pulmonary vein isolation significantly reduces the recurrences of the arrhythmia in patients with atrial fibrillation, although on its own it is not superior to pulmonary vein isolation.

The fact that atrial fibrillation is triggered by ectopic beats, while the atrial substrate appears to play a major role in its maintenance and perpetuation—especially the regions with specific electrophysiological features—leads to the thought that ablation of those regions could improve the results of the therapeutic strategy, contributing to a more effective treatment of both paroxysmal and persistent atrial fibrillation.

In 2004, for the first time, Nademanee described a technique for the location and ablation of complex fractionated atrial electrograms without simultaneous isolation of the pulmonary veins, reporting extremely good results.[5] However, other groups were not able to achieve the same high success rates only by ablating the specific regions.

In contrast, the combination of ablation of the above regions and electrical isolation of the pulmonary veins seems to have very good results. A series of studies examined the outcome of this combination. In the case of persistent atrial fibrillation, most studies and meta-analyses showed that further modification of the substrate improves the patients' outcomes.

In a systematic review of the literature regarding the effect of different ablation strategies on the outcome of persistent atrial fibrillation, it was confirmed that the combination of substrate modification and pulmonary vein isolation was superior to electrical isolation alone, improving the patient's clinical outcome.[6]

The treatment of atrial fibrillation continues to present one of the greatest challenges in modern electrophysiology. A new era began 20 years ago, with the discovery of the importance of ectopic foci within the pulmonary veins for the initiation of the arrhythmia and the successful treatment of the paroxysmal form through their ablation. The results are not so good for persistent atrial fibrillation, where the atrial substrate appears to play a primary role. Various ablation strategies have been examined and evaluated, but none so far has achieved the desired results. However, the combination of atrial substrate modification and focal ablation appears to be gaining ground, although the detection of the ideal ablation targets requires considerable effort.

Ablation of atrial fibrillation continues to develop at a rapid rate. Advances such as robotically controlled catheters and real-time imaging with CT or MRI will help electrophysiologists to achieve excellent results. Innovative techniques and new data are expected to cast further light on a number of questions regarding atrial fibrillation ablation in the near future.

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