Atrial Fibrillation Ablation: Indications, New Advances, and Complications

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Abstract
Atrial fibrillation (AF) is the most common cardiac arrhythmia affecting millions of people worldwide with increasing incidence and prevalence. Radiofrequency catheter ablation has evolved as the treatment of choice for both paroxysmal and persistent AF. Several studies have been reported on catheter ablation as the first-line treatment for paroxysmal AF and different strategies for persistent AF. New technologies such as contact-force sensing catheters and cryoballoon have been recently used and the procedure carries the risk of complications like hematoma, arteriovenous fistula, cardiac tamponade, pulmonary vein stenosis, atrio-esophageal fistula and death.

Keywords: atrial fibrillation; catheter ablation; major complications

Introduction
Atrial fibrillation (AF) is the commonest type of arrhythmia and is seen as a growing public health burden affecting patients’ morbidity and mortality. Since the end of the last century, catheter ablation (CA) has been evolving as the treatment of choice in a particular subset of patients with AF, and currently is the most commonly performed CA procedure worldwide. Most centers have progressively moved from performing CA for paroxysmal AF to performing CA for more complex long-standing persistent AF.

Paroxysmal Atrial Fibrillation Ablation: Should Catheter Ablation Be the First-Line Option?
Following the seminal report by Haissaguerre et al. [1], CA has been a successful treatment option for patients with paroxysmal AF. Multiple clinical trials have established the superiority of CA over antiarrhythmic drug (AAD) therapy for the maintenance of sinus rhythm and improvement of quality of life [2, 3]. Whether CA should be adopted as a first-line therapy remains controversial. Verma [4] suggested CA should be adopted as a first-line therapy for AF; in support of this suggestion, Morillo et al. [5] referenced the results of a pivotal randomized trial (i.e., Radiofrequency Ablation Versus Antiarrhythmic Drugs for Atrial Fibrillation Treatment [RAAFT]), together with additional considerations such as the mortality benefit of sinus rhythm maintenance, the ineffectiveness of AAD therapy for rhythm control of AF, and the significant risks associated with AAD therapy. In a contrasting
article, Padanilam and Prystowsky [6] defended the role of AAD therapy, given the insufficient evidence supporting CA as a first-line therapy, together with the lack of knowledge of the long-term efficacy and risks of CA, the cost-effectiveness of this strategy, and the reproducibility of the results across different institutions and operators. Today, we think that sufficient evidence has been acquired. The RAAFT trial was the first study to suggest the benefit of CA as a first-line therapy for AF. We are looking forward to the outcome of the ongoing CABANA trial.

Ablation of Persistent Atrial Fibrillation: Whom to Ablate and What Is the Best Strategy?

Strategies for Catheter Ablation of Persistent Atrial Fibrillation

The 2C3L is our center’s standard approach for persistent and long-standing persistent AF [7]. This includes two wide-area antral circumferential ablations of the ipsilateral pulmonary vein and three linear ablations at the left atrial roof (roof line), mitral isthmus between the mitral annulus and left inferior pulmonary vein (mitral isthmus line), and cavotricuspid isthmus (cavotricuspid isthmus line). This approach assumes that pulmonary vein isolation (PVI) is an essential step while one is ablating AF [8, 9] and additional linear ablation [10, 11] are performed to modify the atrial substrate. Macroreentry tachycardia, including roof-dependent, perimital-dependent, and cavotricuspid isthmus–dependent macroreentry tachycardia, is frequently seen during the index procedure as a transition from AF to sinus rhythm or as a cause of arrhythmia recurrence after ablation. A recently reported prospective randomized study comparing the stepwise and the 2C3L approach has shown that the 2C3L approach is simple, feasible, efficient, and not inferior to the stepwise approach [7].

The 2C3L strategy simplifies a stepwise procedure by using predefined ablation targets and an “objective” end point. It is associated with an efficacy not inferior to that of the stepwise approach but with shorter procedure time, shorter radiofrequency (RF) delivery, and shorter X-ray exposure. Redo procedures following a 2C3L ablation are easier to perform because most recurrent arrhythmias are mappable organized atrial tachyarrhythmias and ablation lesions created in the initial procedure can be easily identified. The main findings of our prospective randomized study are as follows: (1) in patients with persistent AF, ablation with the 2C3L technique, including PVI and empirical left atrial roof, mitral isthmus, and cavotricuspid isthmus linear ablations, is easy to perform and can achieve a similar 1-year and midterm single-procedure outcome as that associated with the stepwise approach, but with significantly shorter procedure time, fluoroscopy time, and RF time; (2) with an average of 1.4 procedures, 84.9% of patients in the 2C3L group and 80.8% of patients in the stepwise approach group remained in sinus rhythm at 21+7 months; and (3) complex fractionated atrial electrogram ablation and the pursuit of intraprocedural AF termination may not be required to improve the outcome of persistent AF ablation.

Atrial Fibrosis

Extensive research has been conducted on the pathophysiologic mechanism of AF. Daccarett et al. [12] documented a higher degree of fibrosis in persistent AF than in paroxysmal AF. Currently, atrial fibrosis–guided ablation is a novel mechanistic guided ablation strategy [13, 14]. Magnetic resonance imaging provides direct evidence of the extent of fibrosis, whereas indirect evidence is obtained by voltage mapping with use of three-dimensional mapping systems. Additionally, Marrouche et al. [15] reported that an increased area of fibrosis of the left atrial wall detected by late gadolinium-enhanced magnetic resonance imaging is associated with increasing recurrent arrhythmia after CA. Studies are ongoing to prospectively assess the outcome of fibrosis-guided ablation.

New Advances and Technologies

Contact Force Sensing Technology

Electrode-tissue contact is crucial for adequate lesion formation in AF ablation. The advent of contact force sensing technology has made possible real-time assessment of the applied force at the catheter-tissue interface and has increased the chances of transmural lesions. The safety and effi-
Cacy of the contact force sensing catheter have been confirmed in many trials [16].

Martinek et al. [17] enrolled 50 paroxysmal AF patients and assigned them to ablation with either a standard 3.5-mm open-irrigated-tip catheter or a catheter with contact force sensing. The results showed that the use of contact force sensing catheters significantly reduced ablation and procedure times in PVI. Another prospective case-control study demonstrated that availability of real-time contact force information during PVI was associated with a significantly lower acute pulmonary vein reconnection rate [18]. A meta-analysis including nine studies showed that the use of contact force technology decreased AF recurrence at a median follow-up of 12 months (relative risk 0.63; 95% confidence interval 0.44–0.91; P = 0.01) and also led to decreased RF delivery duration during ablation. However, there was no difference in total procedure length and fluoroscopy exposure [19].

Cryoballoon Catheter Ablation for Atrial Fibrillation

Cryoballoon ablation with PVI has emerged in the past few years as novel breakthrough technology for the treatment of drug-refractory AF [20]. It is a relatively simple alternative to point-by-point RF ablation of paroxysmal AF. An ongoing randomized trial (FreezeAF) is examining, for the first time, whether PVI with a cryoballoon is superior to open irrigated RF ablation in patients with paroxysmal AF. Cryoablation works by generating a deep-freeze effect and creating temperatures from –30 to –50 °C at the catheter-tissue interface. Reaching very low temperatures (e.g., lower than –50 °C) is a sign to abruptly stop the cooling process to avoid complications within the pulmonary veins and within adjacent tissues (most often lung lesions are observed). The process of freezing and rewarming tissues results in myocardial cell necrosis and effective lesions. A recent study (STOP AF trial) demonstrated that cryoballoon ablation is a safe and effective alternative to antiarrhythmic medication for the treatment of patients with symptomatic paroxysmal AF for whom treatment with at least one AAD has failed, with risks within accepted standards for ablation therapy [20].

Complications

Increased complication rates have been reported with the increase in the volume and complexity of ablation procedures performed for AF. In a worldwide survey, Cappato et al. [21] reported a major complication rate of 4.5%. Another single-center study, from Johns Hopkins Hospital, reported a major complication rate of 5%, which decreased after the first 100 cases [22]. Vascular access complications are the most common complications, including hematoma, pseudoaneurysm, atriovenous fistula, retroperitoneal hemorrhage, and pneumothorax. Other complications are related to transeptal access, such as aortic puncture, air embolism, and cardiac tamponade. Energy delivery complications include cardiac perforation, atrioesophageal fistula, phrenic nerve palsy, pulmonary vein stenosis, and gastroparesis.

Summary

CA has become a cornerstone in the management of AF. As new strategies and technologies are implemented to improve the success rates of this procedure, prevention and early detection of complications will contribute to reduction of adverse outcomes with this technology.

Conflict of Interest

The author declares no conflict of interest.

REFERENCES

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