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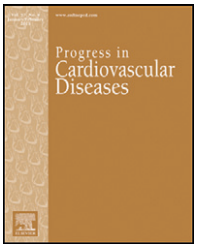

Atrial Fibrillation Ablation: Indications, Emerging Techniques, and Follow-Up

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ABSTRACT

Atrial fibrillation (AF) is the most common cardiac arrhythmia and its prevalence is expected to increase as our population ages. The medical management of AF has yielded only modest success, and over the past 15 years, catheter ablation (CA) has become a mainstay in the treatment for AF. Advancements in the tools used for CA have improved outcomes in patients with both paroxysmal and persistent forms of AF. Additionally, the use of various post-procedure ECG monitoring devices is important for guiding the long-term management of patients with AF. However, long-term AF control in these patients also requires management of other medical comorbidities and risk factors associated with AF.

Atrial fibrillation (AF) is the most common cardiac arrhythmia and is associated with significant mortality and morbidity and considerable socioeconomic impact. Its prevalence is expected to increase to greater than 10 million as our population ages.[1,2] Catheter ablation (CA) has become a mainstay of therapy for select populations with AF. Techniques in CA for AF have evolved significantly over the past decade. This review will highlight the indications for selecting the appropriate patient population for CA, current and emerging techniques in ablation, and the importance of follow-up monitoring in patients who have undergone CA.

Mechanisms of AF

Advancements in techniques for AF ablation have followed from the evolution of our understanding of the complex mechanisms underlying AF. Currently, there are several theories regarding the mechanisms of AF. In the early part of the 20th century, Scherf argued that AF was due to a rapidly firing focus, with such a rapid rate that conduction to the rest of the atrium was inhomogeneous and resulted in "fibrillatory" conduction.[3] In the mid 20th century, Gordon Moe utilized computer simulation and animal models of reentry and proposed an alternative theory. He described that AF was based upon "multiple-reentrant wavelets" that interacted in a self-sustaining manner without any focal "drivers".[4–6] The "multiple-wavelet" hypothesis was further corroborated in studies performed by Allessie and colleagues in the mid 1980s. Importantly, their group did not identify any focal source during AF, and found that the multiple wavelets meandered around the atrium and never reentered the same path.[7–9] In contrast, Jalife and colleagues have described the role of "rotors" as primary engines maintaining AF. Their group proposed that in a heterogeneous atrium, a focal trigger can give rise to stable functional reentrant circuits (rotors) which conduct with irregular fibrillatory conduction to the remaining atria.[10–12] The theory of the "focal" origin of human AF returned in 1998, when Haïssaguerre described that the "triggers" that initiated AF originated from myocardial tissue

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Abbreviations and Acronyms

AADT = anti-arrhythmia drug therapy

AF = atrial fibrillation

AV = atrioventricular

CA = catheter ablation

CFAE = complex fractionated atrial electrogram

ICE = intracardiac echocardiography

GP = ganglionated plexi

LA = left atrium or atrial

LAA = left atrial appendage

MRI = magnetic resonance imaging

PV = pulmonary vein

PVI = pulmonary vein isolation

QoL = quality of life

RF = radiofrequency

WACA = wide-area circumferential ablation

within the pulmonary veins (PVs), and that ablating these focal triggers could cure AF in some patients.[13] Evidence supported that these triggers not only initiated AF, but also contributed to AF maintenance. The ablation procedure evolved over the next decade to its current approach that involves isolation of all four PVs at the PV antrum, commonly referred to as PV isolation (PVI).

Indications and patient selection for AF ablation

The consensus HRS/EHRA/ESC and ACC/AHA/HRS guidelines from 2012 and 2014 recommended CA of paroxysmal AF as a Class I indication for symptomatic patients who were either intolerant of medical therapy, or had breakthrough AF despite a trial of at least one Vaughn Williams Class I or III anti-arrhythmic drug therapy (AADT). For patients with symptomatic persistent or long-standing persistent AF despite use of AADT, the guidelines' levels of recommendations for CA are IIa and IIb, respectively, meaning they are reasonable but more controversial.[14,15] The RAAFT (Radiofrequency Ablation Versus Anti-Arrhythmic Drug Therapy) and MANTRA-PAF (Medical Anti-Arrhythmic Treatment or Radiofrequency Ablation in Paroxysmal Atrial Fibrillation) studies compared the efficacy of CA vs. AADT as first-line therapy for paroxysmal AF patients. In both studies, the CA group had better quality of life (QoL), less symptomatic AF, and increased freedom from AF at 1 year, although the absolute benefits were small.[16,17] More recently, the RAAFT 2 prospective randomized multi-center trial compared an initial strategy of CA with AADT. Patients randomized to primary CA had a higher likelihood of 2-year AF freedom (symptomatic or asymptomatic) compared to those randomized to initial AADT (46% vs. 27%; $p = 0.02$).[18] Based upon these trials, the current guidelines suggest that CA is reasonable (Class IIa) for selected patients with symptomatic paroxysmal AF prior to the use of AADT, if performed at an experienced center.[14,15]

Heart failure (HF) patients with reduced left ventricular ejection fraction (LVEF) have a higher incidence of AF, and can be particularly challenging to manage. Several studies have shown that in patients with systolic HF and AF, even with adequate ventricular rate control, successful CA can lead to a significant improvement in LVEF and HF symptoms.[19,20] The PABA-CHF trial compared PVI to atrioventricular (AV) node ablation with biventricular pacing and found that HF patients who underwent PVI had improved LVEF, 6-minute walk distance and overall QoL compared to the AV node ablation/biventricular pacing group.[21] Therefore, we currently reserve AV node ablation/biventricular pacing for elderly patients, patients with significant comorbidities who would not tolerate CA for AF, or patients with preexisting biventricular implantable cardio-defibrillators and AF with ventricular response rates rapid enough to limit the amount of biventricular pacing.

Prior to consideration of CA, reversible causes of AF should be investigated. These include evaluation for hyperthyroidism, pulmonary embolism, myocardial infarction, heavy alcohol consumption, post cardiac surgery and other acute inflammatory processes. These should be investigated and treated appropriately as treatment of these underlying triggers will often resolve or significantly reduce the arrhythmia burden.[22–24] Furthermore, AF has been associated with other supraventricular tachycardias that may serve as the "trigger" for AF, such as AV nodal reentry, atrioventricular reentry tachycardia, or atrial tachycardia. Eliminating those SVTs may help limit or eliminate episodes of AF.[25]

When catheter ablation for atrial fibrillation is pursued, it should be understood that it is a complex procedure and its risks and benefits including its alternatives should be discussed in detail with each patient. Patient selection for AF ablation is dictated by a considerable number of factors, most importantly the type of underlying AF. Success rates are best in patients with paroxysmal AF (defined as typical duration <7 days with spontaneous conversion to sinus rhythm), while the outcome decreases dramatically once AF becomes persistent (episodes lasting > 7 days or requiring electrical cardioversion for termination) or long-lasting persistent (persistent AF lasting > 1 year).

Several studies from one center have used delayed-enhancement magnetic resonance imaging to try to predict the likelihood of a successful CA. The proportion of pre-existing left atrial (LA) fibrosis has been found to correlate with a lower success rate after CA.[26–28] However, the reproducibility of this technique is unclear and its utility in terms of individual risk stratification, while provocative, requires prospective validation.

Other factors that should be considered prior to undergoing CA are LA size, underlying structural heart disease and candidacy for alternative forms of therapies. Furthermore, obesity and sleep apnea are known comorbidities that increase the incidence and burden of AF. A recent study has demonstrated the importance of weight loss and sleep apnea treatment prior to CA.[29] In one study, weight loss of 15 kg and treatment of sleep apnea with CPAP led to an ~50% improvement in the outcome after CA. We recommend that any obese patient undergo screening for sleep apnea and enroll in a weight loss program prior to undergoing CA. Finally, these procedures are routinely performed under general anesthesia and medical comorbidities that impact the risk of general anesthesia (particularly pulmonary disease or pulmonary hypertension) should also be considered. These