Contemporary Challenges of Catheter Ablation for Atrial Fibrillation

Rukshen Weerasooriya, BMedSc, (Hons), MBBS, FRACP[1]; Ashok J. Shah, MBBS[2]; Meleze Hocini, MD[2]; Pierre Jaïs, MD[2]; and Michel Haïssaguerre, MD[2]

[1]*University of Western Australia, Crawley, Royal Perth Hospital, Perth, Hollywood Private Hospital, Nedlands, Western Australia, Australia; and* [2]*University of Bordeaux, Bordeaux, Hôpital Cardiologique du Haut-Leveque, Pessac, France*

ABSTRACT

Purpose: Catheter ablation of atrial fibrillation (AF) is now one of the most frequently performed ablation procedures, but there are currently 2 important challenges: achieving permanent/durable rather than transient pulmonary vein isolation (PVI) and improving the results of ablation for the wider patient population with persistent AF.

Methods: Recent technical advances in the technique of ablation and the results of clinical trials aimed at achieving more permanent and durable PVI are reviewed. We also summarize recent advances in identifying atrial fibrosis and in understanding the pathophysiology of AF relevant to selecting patients for ablation of persistent AF.

Findings: The use of contact force–sensing technology, adenosine testing after ablation, and pace capture–guided ablation all have the potential for achieving more durable ablation. Selection of patients suitable for ablation of persistent AF may be improved by assessing the extent of atrial fibrosis with delayed enhancement imaging with cardiac magnetic resonance or by assessing the pattern of atrial electrical activity with the use of complex atrial electrograms. Advances in treatment are likely to result from the recognition of localized rotors and focal sources as primary sustaining mechanisms for all types of human AF and in the use of noninvasive mapping for their identification. Linear ablation to supplement PVI may improve the results of AF ablation.

Implications: Rapidly unfolding advances in the techniques of AF ablation and the understanding of mechanisms of AF hold promise for improving the durability of PVI and for extending the technique to carefully selected patients with persistent AF.

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INTRODUCTION

Atrial fibrillation (AF) is the most common sustained arrhythmia, and catheter ablation of AF is now one of the most frequently performed ablation procedures. The aging of the "baby boom" populations in industrialized countries as well as several other factors will likely see this trend accelerate. Randomized, controlled trials have clearly demonstrated the superiority of catheter ablation over pharmacological therapy, albeit in selected patient populations—paroxysmal AF in relatively young patients with minimal left atrial (LA) dilation.[1–3] Catheter ablation of AF continues to evolve rapidly, and we believe that the next decade will see significant improvements in our mechanistic understanding of the disease process, with an emphasis on improved substrate imaging and mapping combined with advances in ablation technologies and techniques that will improve safety and efficacy and widen the indication for catheter ablation. In our opinion, 2 important current challenges exist: achieving permanent/durable rather than transient pulmonary vein isolation (PVI) and improving identification of ablation targets and results of substrate-based ablation for the wider patient population with persistent AF.

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DURABLE PULMONARY VEIN ABLATION

The highest success rates for AF ablation are reported in those patients with a structurally normal heart and paroxysmal rather than persistent AF. The latest consensus guidelines recommend AF ablation largely for those patients who are symptomatic and in whom at least 1 antiarrhythmic drug has failed.[4] Even in this "ideal" group, repeat procedures are required in a significant proportion of patients. In the Thermocool AF trial, repeat procedures were performed in 12.6% of patients,[3] whereas redo procedures were performed in 43.4% in the A4 study[2] and in 15.2% in the RAAFT-2 [Radiofrequency Ablation vs Antiarrhythmic Drugs as First-Line Treatment of Paroxysmal Atrial Fibrillation] study.[1] The most common reason for repeat ablation is pulmonary vein (PV) conduction recovery due to incomplete initial ablation, which is most likely related to the acute formation of tissue edema.[5]

Contact Force

At the present time, several strategies can be used to reduce the chances of PV conduction recovery. An important recent development has been the use of contact force–sensing technology. It has been clearly demonstrated that even highly experienced operators do not accurately judge catheter contact by tactile feedback alone.[6] Contact force–sensing technology enables careful titration of energy delivery and better evaluation of actual lesion formation by calculation of the force time integral (amount of contact applied over time) and lesion size index (amount of contact and power applied over time).[7] A key finding of the EFFICAS-1 trial was that the lesion with the least contact plays a critical role in PV conduction recovery (ie, every lesion counts).[8] Contact force–sensing technology also has obvious benefits in terms of risk reduction. The logical next step for contact-force technology is the development of automated ablation algorithms using force time integral and lesion size index as well as technologies to achieve stable catheter contact such as steerable sheaths and magnetic navigation.

Adenosine

Since the first descriptions of adenosine awakening "dormant" PV conduction in 2004,[9] there has been interest in using adenosine testing to improve the durability of PV isolation. Adenosine transiently hyperpolarizes the resting membrane potential of ablated PVs and restores excitability (so-called dormant conduction or reconduction)[10] in 50% of isolated PVs. In a nonrandomized series, adenosine testing after PVI with additional ablation targeting dormant conduction has reduced repeat-procedure rates by ∼50%.[11] A large, multicenter, randomized study (ADVICE [ADenosine Following Pulmonary Vein Isolation to Target Dormant Conduction Elimination]) was designed to determine whether adenosine testing should routinely be implemented after PVI to reduce clinical recurrence and therefore redo procedures.[11]

Pace Capture–Guided Ablation

The pace capture–guided ablation strategy has been proposed as a method to improve the durability of PVI. Using this approach, after completion of PVI, pacing is performed along the antral ablation line encircling the ipsilateral PVs.[12,13] Where local LA capture is identified, additional ablation can be performed with the goal of closure of the residual gaps. In a recent randomized study, this technique improved near-term procedural success (12 months) from 52% to 82.7%.

UNDERSTANDING AND ABLATING THE ATRIAL SUBSTRATE

Imaging

Cardiac magnetic resonance imaging with delayed enhancement has been described as a technique to visualize and quantify the amount of pre-existing atrial fibrosis.[14] The recently published DECAAF (Delayed Enhancement MRI (DE MRI) Determinant of Successful Radiofrequency Catheter Ablation of Atrial Fibrillation) multicenter study supported previous extensive studies from a single center demonstrating that quantification of pre-existing LA fibrosis can predict the outcomes of catheter ablation of AF.[15] There was a significantly lower likelihood of success as the cumulative area of delayed enhancement increases. This type of imaging is also providing important insights into the atrial substrate including the anchoring of critical areas of complex fractionated atrial electrograms (CFAEs) at border zones of pre-existing scar.[16] Cutting-edge "joint lab" design enables the patient to undergo intraprocedural magnetic resonance imaging scanning, and imaging sequences are being developed with the aim of acutely distinguishing durable (full-thickness necrosis) from transient (edema) lesions. The future use of stronger magnets with improving image resolution as well as