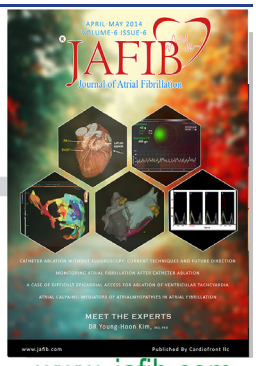
JAFIB
Guest Editorial
Journal of Atrial Fibrillation



www. jafib.com

Putative Role of Right Atrial Ablation in Atrial Fibrillation

Lindsey A. Burnett, PhD[1], and Abraham G. Kocheril, MD, FACC, FACP, FHRS[1,2,3]

[1]College of Medicine, University of Illinois at Urbana Champaign, Urbana, IL. [2]Christie Clinic, Champaign, IL. [3]Presence Covenant Medical Center, Urbana, IL

Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia and associated with significant morbidity and mortality. AF is currently estimated to affect over seven million people worldwide and is predicted to increase in prevalence.[1,2] Medical, surgical, and interventional approaches have been utilized to treat AF. Systemic toxicity and limited therapeutic efficacy of antiarrhythmic medications has resulted in extensive development of surgical and interventional techniques for treatment of AF. In addition to limiting the use of antiarrhythmic medications, these approaches have the added benefit of restoration of normal sinus rhythm (NSR). Although restoration of NSR was not shown to be superior to a rate control management strategy in the AFFIRM trial, follow-up analysis indicated a 47% reduction in mortality associated with the presence of NSR.[3] Maintenance of NSR presumably provides an increase in cardiac output due to restoration of atrial systolic function and allows for the possible cessation of anticoagulation thus reducing risk of bleeding.

Surgical and interventional restoration of NSR has focused on disruption of abnormal atrial circuits thought to underlie AF. Historically the Cox-Maze procedure has involved multiple incisions across the right and left atria resulting in transmural lesions designed to block re-entrant currents, with incision sets evolving to the Cox-Maze III set. Although this procedure was widely successful in treatment of AF, it was not routinely performed due to technical complexity. Subsequent studies revealed that lesions made during the Cox-Maze III procedure could be performed using bipolar radiofrequency alone safely and reproducibly.[4] The latest variant of the Cox-Maze procedure utilizes bipolar radiofrequency ablation and cryoablation to create lesions, in addition to surgical excision of the left atrial appendage. The Cox-Maze IV lesion set is comprised of multiple lesions in both the right and left atria. The left atrial lesion set consists of: 1) right and left pulmonary vein isolation, 2) connecting lesions between the left and right superior and inferior pulmonary veins, and 3) a lesion from the excision site of the left atrial appendage to the pulmonary vein and a lesion to the mitral valve annulus. The right atrial lesion set consists of: 1) ablation lines along the superior and inferior vena cavae and 2) the free wall of the right atrium down to the tricuspid valve annulus (2). Initial studies demonstrate the success of the Cox-Maze IV procedure in AF with freedom from AF and antiarrhythmic drugs at 78-82% at 12 months even in patients with increased left atrial size.[5,6] Complete elimination of AF has been shown in more than 90% of patients treated with Cox-Maze procedures, establishing these procedures as the gold standard for treatment of AF.[7] Additional studies have shown an added benefit of surgical ablation over catheter ablation of 15.7-33.4% with excellent overall rates of AF elimination of 74.7-88%.[8] Surgical procedures have demonstrated increased success in termination of AF compared to percutaneous catheter ablations with one year post-procedure success rates of 65% compared to 36% in the FAST trial; however, procedural adverse event rate was also significantly higher in this group.[9,10] The increased risk of procedural complications with surgical approaches has promoted continued development of catheter-based procedures using radiofrequency energy to create atrial lesions.

Catheter ablation is less effective than surgical approaches, but has fewer procedural complications and is significantly more effective than anti-arrhythmic medications alone.[8,11,12] Landmark work documenting ectopic beat origination in the pulmonary veins[13] has served as the foundation for now-standard catheter-based approaches. Consequently, catheter-based ablations have focused on the left atrium, with a particular emphasis on pulmonary vein isolation.[14] Conventional catheter ablation has been shown to have one year success rate (elimination of AF without anti-arrhythmic drugs) of 40-60% for one procedure with a 70-80% maximal success

Guest Editor - JAFIB
Professor of Medicine,
University of Illinois.

Dr. Abraham G. Kocheril, MD , FACC, FACP, FHRS

rate for three or more procedures.[11,12,14-16] Although catheter-based procedures are effective and have the benefit of minimal invasiveness they remain inferior when compared to Cox-Maze procedures.

One potential explanation for the relative success of Cox-Maze procedures III and IV compared to catheter-based ablation is electrical intervention in both left and right atria, which suggests a putative role for right atrial catheter ablation. Although right atrial ablation approaches have been previously documented, more recent studies incorporating atrial mapping have further elucidated the role of the right atrium in AF. Right atrial foci in the SVC, crista terminalis, and coronary sinus ostium have been speculated to initiate AF. Since AF predominantly originates in the left atrium some studies have shown little additional benefit of right atrial lesions particularly in patients with long-lasting persistent AF.[17] however, studies utilizing atrial mapping have suggested a role for focal right atrial ablation. Atrial mapping, specifically of paroxysmal AF suggests that between 5-25% of AF may originate in the right atrium; once mapped, focal ablation of the right atrium can effectively treat this subset of paroxysmal AF with long-term success in maintenance of sinus rhythm without AADs of 79% of patients at 19.7 months.[18-20] Right atrial foci have also been identified in idiopathic AF; mapping and right atrial linear ablations successfully eliminated or allowed AF to be medically managed in 56% of these patients.[21] Logically, biatrial procedures have been shown to have the highest success rates of catheter-based approaches, with success rates of up to 85%[22] approaching success rates seen with Cox-Maze procedures.

The success of catheter-based ablation with specific targeted lesions is improving because of recent developments in the understanding of the generation and sustenance of AF. The critical mass hypothesis describes the tendency of fibrillation to terminate in a finite-sized tissue; sustenance of fibrillation has been directly correlated with tissue area-- consistent with clinical data correlating increased atrial size with persistence of AF.[23] Recent studies have revealed that AF is typically generated by a small number of localized sources that cause disorganization in the remaining atrial tissue.[16,24,25] The CONFIRM study examined conventional ablation with and without focal impulse and rotor ablation. Atrial mapping revealed electrical rotors and focal impulses in 97% of AF patients with a median number of 2.1+/- 1.0 sources (70% rotors and 30% focal impulses). Focal impulse and rotor modulation (FIRM) ablation was used to eliminate these foci before conventional ablation. Acutely 86% of persistent and paroxysmal either terminated or slowed AF and single procedure AF elimination rates were 82.4% in FIRM-guided compared to 44.9% in FIRM-blinded cases. In addition, this approach resulted in improvement in long-term AF elimination compared to conventional ablation strategies.[16] These findings suggest a critical role for novel atrial mapping technologies and targeted ablation to precisely deliver lesions to treat unique patient-specific foci. In US centers using this technique, about a third of the rotors are found in the right atrium (unpublished data).

It is important to review the history of catheter ablation of atrial fibrillation, and consider the judicious addition of potentially impactful right atrial lesions, at least in select cases. Whether guided by mapping of rotors or complex fractionated atrial electrograms (CFAE), or simply anatomic lesion sets, these additional lesions have the potential to improve success rates and deserve further investigation. Some of their benefit may derive from the proximity of the right superior pulmonary vein and other key structures, as right atrial lesions are delivered. Some of the reported benefits may be from a reduction of the critical mass of atrial myocardium available to sustain AF. Since right atrial lesions are generally safer than left atrial lesions, adding these would be associated with minimal additional risk to the patient. In our quest to improve the success rates and reduce the complications associated with catheter ablation of AF, the right atrium should not be forgotten. The future is likely to be about individualization of therapies, partly from detailed mapping and targeted ablation lesions.

References:

1. Miyasaka Y, Barnes ME, Gersh BJ, Cha SS, Bailey KR, Abhayaratna WP, Seward JB, Tsang TS 2006 Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence. Circulation 114:119-125
2. Robertson JO, Lawrance CP, Maniar HS, Damiano RJ, Jr. 2013 Surgical techniques used for the treatment of atrial fibrillation. Circulation journal : official journal of the Japanese Circulation Society 77:1941-1951
3. Corley SD, Epstein AE, DiMarco JP, Domanski MJ, Geller N, Greene HL, Josephson RA, Kellen JC, Klein RC, Krahn AD, Mickel M, Mitchell LB, Nelson JD, Rosenberg Y, Schron E, Shemanski L, Waldo AL, Wyse DG 2004 Relationships between sinus rhythm, treatment, and survival in the Atrial Fibrillation Follow-Up Investigation of Rhythm Management (AFFIRM) Study. Circulation 109:1509-1513
4. Benussi S, Galanti A, Nascimbene S, Fumero A, Dorigo E, Zerbi V, Alfieri O 2009 Complete right atrial ablation with bipolar radiofrequency. The Annals of thoracic surgery 87:1573-1576
5. Weimar T, Bailey MS, Watanabe Y, Marin D, Maniar HS, Schuessler RB, Damiano RJ, Jr. 2011 The Cox-maze IV procedure for lone atrial fibrillation: a single center experience in 100 consecutive patients. Journal of interventional cardiac electrophysiology : an international journal of arrhythmias and pacing 31:47-54
6. Damiano RJ, Jr., Schwartz FH, Bailey MS, Maniar HS, Munfakh NA, Moon MR, Schuessler RB 2011 The Cox maze IV procedure: predictors of late recurrence. The Journal of thoracic and cardiovascular surgery 141:113-121
7. Toeg HD, Al-Atassi T, Lam BK 2014 Atrial Fibrillation Therapies: Lest We Forget Surgery. The Canadian journal of cardiology
8. Wazni OM, Marrouche NF, Martin DO, Verma A, Bhargava M, Saliba W, Bash D, Schweikert R, Brachmann J, Gunther J, Gutleben K, Pisano E, Potenza D, Fanelli R, Raviele A, Themistoclakis S, Rossillo A, Bonso A, Natale A 2005 Radiofrequency ablation vs antiarrhythmic drugs as first-line treatment of symptomatic atrial fibrillation: a randomized trial. JAMA : the journal of the American Medical Association 293:2634-2640
9. Boersma LV, Castella M, van Boven W, Berruezo A, Yilmaz A, Nadal M, Sandoval E, Calvo N, Brugada J, Kelder J, Wijffels M, Mont L 2012 Atrial fibrillation catheter ablation versus surgical ablation treatment (FAST): a 2-center randomized clinical trial. Circulation 125:23-30
10. Zembala MO, Suwalski P 2013 Minimally invasive surgery for atrial fibrillation. Journal of thoracic disease 5:S704-S712
11. Oral H, Pappone C, Chugh A, Good E, Bogun F, Pelosi F, Jr., Bates ER, Lehmann MH, Vicedomini G, Augello G, Agricola E, Sala S, Santinelli V, Morady F 2006 Circumferential pulmonary-vein ablation for chronic atrial fibrillation. The New England journal of medicine 354:934-941
12. Wilber DJ, Pappone C, Neuzil P, De Paola A, Marchlinski F, Natale A, Macle L, Daoud EG, Calkins H, Hall B, Reddy V, Augello G, Reynolds MR, Vinekar C, Liu CY, Berry SM, Berry DA 2010 Comparison of antiarrhythmic drug therapy and radiofrequency catheter ablation in patients with paroxysmal atrial fibrillation: a randomized controlled trial. JAMA : the journal of the American Medical

Association 303:333-340
13. Haissaguerre M, Jais P, Shah DC, Takahashi A, Hocini M, Quiniou G, Garrigue S, Le Mouroux A, Le Metayer P, Clementy J 1998 Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. The New England journal of medicine 339:659-666
14. Calkins H, Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA, Crijns HJ, Damiano RJ, Jr., Davies DW, DiMarco J, Edgerton J, Ellenbogen K, Ezekowitz MD, Haines DE, Haissaguerre M, Hindricks G, Iesaka Y, Jackman W, Jalife J, Jais P, Kalman J, Keane D, Kim YH, Kirchhof P, Klein G, Kottkamp H, Kumagai K, Lindsay BD, Mansour M, Marchlinski FE, McCarthy PM, Mont JL, Morady F, Nademanee K, Nakagawa H, Natale A, Nattel S, Packer DL, Pappone C, Prystowsky E, Raviele A, Reddy V, Ruskin JN, Shemin RJ, Tsao HM, Wilber D 2012 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design. Journal of interventional cardiac electrophysiology : an international journal of arrhythmias and pacing 33:171-257
15. Haissaguerre M, Sanders P, Hocini M, Takahashi Y, Rotter M, Sacher F, Rostock T, Hsu LF, Bordachar P, Reuter S, Roudaut R, Clementy J, Jais P 2005 Catheter ablation of long-lasting persistent atrial fibrillation: critical structures for termination. Journal of cardiovascular electrophysiology 16:1125-1137
16. Narayan SM, Krummen DE, Shivkumar K, Clopton P, Rappel WJ, Miller JM 2012 Treatment of atrial fibrillation by the ablation of localized sources: CONFIRM (Conventional Ablation for Atrial Fibrillation With or Without Focal Impulse and Rotor Modulation) trial. Journal of the American College of Cardiology 60:628-636
17. Oral H, Chugh A, Good E, Crawford T, Sarrazin JF, Kuhne M, Chalfoun N, Wells D, Boonyapisit W, Gadeela N, Sankaran S, Kfahagi A, Jongnarangsin K, Pelosi F, Jr., Bogun F, Morady F 2008 Randomized evaluation of right atrial ablation after left atrial ablation of complex fractionated atrial electrograms for long-lasting persistent atrial fibrillation. Circulation Arrhythmia and electrophysiology 1:6-13
18. Chen SA, Tai CT, Yu WC, Chen YJ, Tsai CF, Hsieh MH, Chen CC, Prakash VS, Ding YA, Chang MS 1999 Right atrial focal atrial fibrillation: electrophysiologic characteristics and radiofrequency catheter ablation. Journal of cardiovascular electrophysiology 10:328-335
19. Kocheril AG 2001 Right atrial mapping and linear ablation for paroxysmal atrial fibrillation. Journal of interventional cardiac electrophysiology : an international journal of arrhythmias and pacing 5:505-510
20. Lin YJ, Tai CT, Kao T, Tso HW, Huang JL, Higa S, Yuniadi Y, Huang BH, Liu TY, Lee PC, Hsieh MH, Chen SA 2005 Electrophysiological characteristics and catheter ablation in patients with paroxysmal right atrial fibrillation. Circulation 112:1692-1700
21. Gaita F, Riccardi R, Calo L, Scaglione M, Garberoglio L, Antolini R, Kirchner M, Lamberti F, Richiardi E 1998 Atrial mapping and radiofrequency catheter ablation in patients with idiopathic atrial fibrillation. Electrophysiological findings and ablation results. Circulation 97:2136-2145
22. Pappone C, Rosanio S, Oreto G, Tocchi M, Gugliotta F, Vicedomini G, Salvati A, Dicandia C, Mazzone P, Santinelli V, Gulletta S, Chierchia S 2000 Circumferential radiofrequency ablation of pulmonary vein ostia: A new anatomic approach for curing atrial fibrillation. Circulation 102:2619-2628
23. Qu Z 2006 Critical mass hypothesis revisited: role of dynamical wave stability in spontaneous termination of cardiac fibrillation. American journal of physiology Heart and circulatory physiology 290:H255-263
24. Nademanee K, Lockwood E, Oketani N, Gidney B 2010 Catheter ablation of atrial fibrillation guided by complex fractionated atrial electrogram mapping of atrial fibrillation substrate. Journal of cardiology 55:1-12
25. Nademanee K, McKenzie J, Kosar E, Schwab M, Sunsaneewitayakul B, Vasavakul T, Khunnawat C, Ngarmukos T 2004 A new approach for catheter ablation of atrial fibrillation: mapping of the electrophysiologic substrate. Journal of the American College of Cardiology 43:2044-2053