Editorial

Pulmonary Vein Ablation for Atrial Fibrillation: Where Do We Stand, What More Can We Expect?

SHIH-ANN CHEN

Division of Cardiology, Department of Medicine, National Yang-Ming University, School of Medicine and Taipei Veterans General Hospital, Taipei, Taiwan

Key words:
Atrial fibrillation, pulmonary veins, ablation.

Manuscript received:
March 3, 2004;
Accepted:
April 20, 2004.

Address:
Shih-Ann Chen

Division of Cardiology, Taipei Veterans General Hospital, 201 Sec 2, Shih-Pai Road, Taipei, Taiwan
e-mail:
epsachen@ms41.hinet.net

Most paroxysmal atrial fibrillation (AF) is initiated by ectopic beats from a focal area that is amenable to cure by radiofrequency catheter ablation.[1,2] Persistent AF is usually maintained by an atrial substrate that accommodates multiple reentrant wavelets.[3,4] Although focal triggers of AF may be found in the superior vena cava, crista terminalis, coronary sinus, vein of Marshall, interatrial septum, or left atrial posterior wall, most ectopic foci are located within the pulmonary veins.[5-8]

Haissaguerre's group first recognized the pulmonary veins as the main source of triggers initiating paroxysmal AF.[1] Focal triggers that are identified as rapidly firing ectopic foci in and around the pulmonary veins elicit a short burst of focal discharges, initiating an AF episode that subsequently continues independently. Ablation targeted at the initiating foci can eliminate pulmonary vein extrasystoles, repetitive bursts of vein activity, as well as AF ("focally-initiated" AF). Moreover, several studies have demonstrated slow and/or rapid pulmonary vein activations during AF or after isolation of the pulmonary vein from the atria, thereby suggesting that pulmonary vein activity may also have a role in maintaining (not just initiating) AF.[9,10] These critical findings shed light on the important interplay between atrial substrate and pulmonary vein trigger in AF pathophysiology. Three important issues need further discussion in this era of interventional electrophysiology for ablation of AF.

Limitations and controversies of pulmonary vein ablation

The important concept of AF ablation is the isolation of the pulmonary veins from the atria, thus rendering it impossible for pulmonary vein ectopic beats to be conducted to the atria for the initiation of AF.[11-23] Although the numbers of catheter ablation procedures for AF using the pulmonary vein isolation technique are increasing rapidly, there are still some important limitations and controversies concerning the concept, technique and results of current ablation therapy for AF.

First, the concept of complete pulmonary vein isolation for successful AF ablation is still controversial. Stabile et al demonstrated the complete isolation of 4 pulmonary veins in around 5% of patients without AF recurrence after successful AF ablation: however, the Marchlimski and Cappato groups proved that complete pulmonary vein isolation is necessary, because a lower AF recurrence rate could be obtained after 2 to 3 repeated procedures to obtain complete elimination of any connection between the atria and the pulmonary veins.[17,18,21] Second, pulmonary vein isolation alone seems to

have limited efficacy in persistent AF. Third, current reports from different centers show a large variation in success rate, recurrence rate, complication rate, follow-up tools and follow-up periods. More trials, including large-scale randomized studies comparing different ablation approaches, would be useful in order to determine the best method (high success rate, low complication rate and recurrence rate) for ablation of AF.

Non-pulmonary vein ectopy in AF

It is possible that not only pulmonary vein ectopy, but also non-pulmonary vein ectopy may be able to initiate AF. This laboratory first proposed the important concept of non-pulmonary vein ectopy from different areas initiating paroxysmal AF.[5,7,8] At the present time, most laboratories perform isolation of all 4 pulmonary veins. Thus, recurrent AF from non-pulmonary vein foci should be considered when all 4 pulmonary veins have been successfully isolated. Lin et al demonstrated that paroxysmal AF can be initiated by ectopic beats (around 28% of AF foci) originating from non-pulmonary vein areas, and that the application of radiofrequency energy in the non-pulmonary vein areas is an effective and safe way to treat paroxysmal AF.[8] However, less than 10% of the 240 patients had a single focus from the non-pulmonary vein areas. In an earlier study, Haissaguerre reported that 8.9% of patients had AF from non-pulmonary vein areas, including 6.7% from the right atrium and 2.2% from the left atrial free wall.[1] However, the same group reported a high (79%) incidence of non-pulmonary vein foci initiating AF after pulmonary vein disconnection in 160 patients with AF, and these non-pulmonary vein areas included the adjacent posterior wall around the pulmonary vein ostium, left atrial tissue away from the pulmonary vein ostia, right atrium, coronary sinus, superior vena cava, and several foci (19%) which could not be localized.[24] Therefore, based on these reports, non-pulmonary vein ectopy is important in AF initiation.

Pulmonary vein isolation plus ablation of atrial substrate

The most impressive results from surgical ablation reports provide further evidence for the concept of the left atrium, in particular the pulmonary veins and the area in between them, being deeply involved in the initiation and/or maintenance of AF. Thus, ablation lesions encompassing the periostial atrial tissues and connecting the inferior pulmonary veins to the mitral annulus may be a necessary component in the ablation of AF. A progressive change in the atrial substrate's susceptibility to fibrillate once ectopy emerges is a possible cause of AF recurrence. Modification of the atrial arrhythmogenic substrate seems to be a part of curative ablation strategy for AF in cases with longer AF duration and larger atria. Nademanee et al demonstrated that more than 91% of patients with paroxysmal or chronic AF were free of arrhythmia events after catheter ablation of left atrial arrhythmogenic substrates, including the areas with fragmentation, double potentials, and low voltage electrogram.[25]

Linear ablation in the mitral isthmus, and in the roof of the left atrium joining the 2 superior pulmonary veins can be expected to increase the success rate, but this may be tempered by the possibility of increasing the complications of ablation (cardiac tamponade and stroke), potential for left atrial flutter, and loss of left atrial transportation.[26-28] Because several investigators showed similar results from catheter ablation for paroxysmal AF without adding any linear lesions in the left atrium, it is necessary to identify the patients who would truly benefit from the addition of left atrial linear ablation versus pulmonary vein electrical isolation alone.

Although most laboratories perform catheter ablation of the right atrial cavotricuspid isthmus after isolation of the pulmonary veins in patients with AF associated with clinically documented or induced typical atrial flutter, Wazni et al found no benefit from right atrium isthmus ablation in patients undergoing a pulmonary vein isolation procedure.[29] Furthermore, ablation of the crista terminalis gap and channels between right atrial low voltage zones would be helpful in the elimination of AF caused by a rapid reentry circuit with fibrillatory conduction.[30]

Future concepts

The paradigm for AF ablation has changed dramatically from modifying the atrial substrate of ongoing AF to elimination of the focal triggers that initiate AF. However, ablation of AF triggers plus modification of the atrial substrate may be necessary in some patients with long-lasting AF, or some patients with a significant atrial substrate problem. It is anticipated that continued technological improvements will facilitate the AF-curative ablation te-

chniques and broaden indications for ablation as a treatment of AF. Thus, we can expect to cure an increasing recognized proportion of patients with AF, with the promise of more widespread applications of the evolving AF treatment strategies.

References

1. Haissaguerre M, Jais P, Shah DC, et al: Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. N Engl J Med 1998; 339: 659-666.
2. Chen SA, Hsieh MH, Tai CT, et al: Initiation of atrial fibrillation by ectopic beats originating from the pulmonary veins: Electrophysiologic characteristics, pharmacologic response, and effects of radiofrequency ablation. Circulation 1999; 100: 1879-1886.
3. Allessie MA, Boyden PA, Camm AJ, et al: Pathophysiology and prevention of atrial fibrillation. Circulation 2001; 103: 769-777.
4. Nattel S: New ideas about atrial fibrillation 50 years on. Nature 2002; 415: 219-226.
5. Chen SA, Tai CT, Yu WC, et al: Right atrial focal atrial fibrillation: Electrophysiologic characteristics and radiofrequency catheter ablation. J Cardiovasc Electrophysiol 1999; 10: 328-335.
6. Hwang C, Karagueuzian HS, Chen PS: Idiopathic paroxysmal atrial fibrillation induced by a focal discharge mechanism in the left superior pulmonary vein: possible roles of the ligament of Marshall. J Cardiovasc Electrophysiol 1999; 10: 636-648.
7. Tsai CF, Tai CT, Hsieh MH, et al: Initiation of atrial fibrillation by ectopic beats originating from the superior vena cava: Electrophysiological characteristics and results of radiofrequency ablation. Circulation 2000; 102: 67-74.
8. Lin WS, Tai CT, Hsieh MH, et al: Catheter ablation of paroxysmal atrial fibrillation initiated by non-PV ectopy. Circulation 2003; 107: 3176-3183.
9. Takahashi Y, Iesaka Y, Takahashi A, et al: Reentrant tachycardia in pulmonary veins of patients with paroxysmal atrial fibrillation. J Cardiovasc Electrophysiol 2003; 14: 927-932.
10. Weerasooriya R, Jais P, Scavee C, et al: Dissociated pulmonary vein arrhythmia: incidence and characteristics. J Cardiovasc Electrophysiol 2003; 14: 1173-1179.
11. Haissaguerre M, Shah DC, Jais P, et al: Electrophysiological breakthroughs from the left atrium to the pulmonary veins. Circulation 2000; 102: 2463-2465.
12. Pappone C, Rosanio S, Oreto G, et al: Circumferential radiofrequency ablation of pulmonary vein ostia: A new anatomic approach for curing atrial fibrillation. Circulation 2000; 102: 2619-2628.
13. Mangrum JM, Mounsey JP, Kok LC, et al: Intracardiac echocardiography-guided, anatomically based radiofrequency ablation of focal atrial fibrillation originating from pulmonary veins. J Am Coll Cardiol 2002; 39: 1973-1983.
14. Oral H, Knight BP, Tada H, et al: Pulmonary vein isolation for paroxysmal and persistent atrial fibrillation. Circulation 2002; 105: 1077-1081.
15. Marrouche NF, Martin DO, Wazni O, et al: Phased-array intracardiac echocardiography monitoring during pulmonary vein isolation in patients with atrial fibrillation: impact on outcome and complications. Circulation 2003; 107: 2710-2716.
16. Cappato R, Negroni S, Pecora D, et al: Prospective assessment of late conduction recurrence across radiofrequency lesions producing electrical disconnection at the pulmonary vein ostium in patients with atrial fibrillation. Circulation 2003; 108: 1599-1604.
17. Gerstenfeld EP, Callans DJ, Dixit S, et al: Incidence and location of focal atrial fibrillation triggers in patients undergoing repeat pulmonary vein isolation: implications for ablation strategies. J Cardiovasc Electrophysiol 2003; 14: 685-690.
18. Marchlinski F, Callans D, Dixit S, et al: Efficacy and safety of targeted focal ablation versus PV isolation assisted by magnetic electroanatomic mapping. J Cardiovasc Electrophysiol 2003; 14: 358-365.
19. Deisenhofer I, Schneider MA, Bohlen-Knauf M, et al: Circumferential mapping and electric isolation of pulmonary veins in patients with atrial fibrillation. Am J Cardiol 2003; 91: 159-163.
20. Hsieh MH, Tai CT, Tsai CF, et al: Clinical outcome of very late recurrence of atrial fibrillation after catheter ablation of paroxysmal atrial fibrillation. J Cardiovasc Electrophysiol 2003; 14: 598-601.
21. Stabile G, Turco P, Rocca VL, et al: Is pulmonary vein isolation necessary for curing atrial fibrillation? Circulation 2003; 108: 657-660.
22. Arentz T, Rosenthal J, Blum T, et al: Feasibility and safety of pulmonary vein isolation using a new mapping and navigation system in patients with refractory atrial fibrillation. Circulation 2003; 108: 2484-2490.
23. Lee SH, Tai CT, Hsieh MH, et al: Predictors of early and late recurrence of atrial fibrillation after catheter ablation of paroxysmal atrial fibrillation. J Interv Card Electrophysiol 2004; (in press).
24. Shah D, Haissaguerre M, Jais P, Hocini M: Nonpulmonary vein foci: do they exist? Pacing Clin Electrophysiol 2003; 26: 1631-1635.
25. Nademanee K, McKenzie J, Kosar E, et al: A new approach for catheter ablation of atrial fibrillation: mapping of the electrophysiological substrate. J Am Coll Cardiol 2004; (in press).
26. Oral H, Scharf C, Chugh A, et al: Catheter ablation for paroxysmal atrial fibrillation: segmental pulmonary vein ostial ablation versus left atrial ablation. Circulation 2003; 108: 2355-2360.
27. Ernst S, Ouyang F, Lober F, et al: Catheter-induced linear lesions in the left atrium in patients with atrial fibrillation: an electroanatomic study. J Am Coll Cardiol 2003; 42: 1271-1281.
28. Hsu LF, Jaïs P, Sanders P, et al: Catheter ablation of pulmonary vein atrial fibrillation-segmental and limited linear ablation. In: Chen SA, Haissaguerre M, Zipes DP (eds.): Thoracic vein arrhythmias: Mechanisms and treatment. Blackwell Publishing, Elmsford, USA, 2004; (in press).
29. Wazni O, Marrouche NF, Martin DO, et al: Randomized study comparing combined pulmonary vein-left atrial junction disconnection and cavotricuspid isthmus ablation versus pulmonary vein-left atrial junction disconnection alone in patients presenting with typical atrial flutter and atrial fibrillation. Circulation 2003; 108: 2479-2483.
30. Liu TY, Tai CT, Chen SA: Treatment of atrial fibrillation by catheter ablation of conduction gaps in the crista terminalis and cavotricuspid isthmus of the right atrium. J Cardiovasc Electrophysiol 2002; 13: 1044-1046.