ATRIAL FIBRILLATION

COMPLEX CASE STUDY

Atrial Flutter with Alternating Cycle Lengths: Mechanism and Mapping

¹JUNA MISIRI, MD, ²ROBERT J. KIM, MD and ¹FRED M. KUSUMOTO, MD

¹Division of Cardiovascular Diseases, Department of Medicine, Mayo Clinic, Jacksonville, FL

²Division of Cardiology, Department of Medicine, University of Florida, Jacksonville, FL

KEYWORDS. *arrhythmia, atrial fibrillation, atrial tachycardia.*

ISSN 2156-3977 (print)
ISSN 2156-3993 (online)

© 2012 Innovations in Cardiac
Rhythm Management

Case presentation

A 69-year-old woman with a 10-year history of paroxysmal atrial fibrillation was initially treated with propafenone and amiodarone. Four years ago her arrhythmia burden worsened and she developed recurrent episodes of symptomatic persistent atrial fibrillation. After several cardioversions, she was referred to our institution for radiofrequency catheter ablation. Her amiodarone was discontinued, and 1 year ago she underwent radiofrequency catheter ablation using a pulmonary vein antral isolation approach. Unfortunately, she developed recurrent atrial fibrillation and remained extremely symptomatic despite adequate control of her heart rate. Six months ago, she underwent a second radiofrequency catheter ablation procedure. Electrophysiology study revealed recurrent conduction between all four pulmonary veins and the left atrium, and the veins were reisolated and linear ablations were performed on the roof of the left atrium and the cavotricuspid isthmus. After the ablation, no atrial tachycardia or atrial fibrillation could be induced with aggressive pacing protocols. Unfortunately, she developed recurrent persistent atrial fibrillation within 1 week of the procedure. Four months later she underwent cardioversion with initiation of dofetilide. Two days after starting dofetilide she developed atypical atrial flutter and was referred for a third electrophysiology study.

Surface ECG revealed upright P waves in leads V₁ and V₂ but were poorly seen in the other leads. At electrophysiology study, a circular mapping catheter placed in the four pulmonary veins demonstrated no electrical activity during atrial tachycardia, confirming adequate pulmonary vein isolation. At baseline the atrial tachycardia had stable alternating cycle lengths of 365 ms and 410 ms. Initial pacing maneuvers from the anterolateral right atrium and the proximal and distal coronary sinus yielded post-pacing intervals with long return cycle lengths. In addition, constant fusion and progressive fusion during pacing from the right atrium and the coronary sinus were observed. In order to delineate the tachycardia circuit a 64-electrode basket catheter was placed in the posterior left atrium (**Figure 1**). At baseline, electrograms could be recorded for 318 ms of the 363-ms and 411-ms cycle lengths (88% and 77% respectively) over a large area in the posterior left atrium. The deflection of the P wave corresponded to activation of the superior and anterior portions of the left atrium.

We mapped the tachycardia circuit by identifying the initial site of cycle length change that localized the critical isthmus to the posterior roof of left atrium near the right superior pulmonary vein (**Figure 2**). When the mapping catheter was moved septally or laterally, split potentials suggestive of a line of conduction block were observed and a 20-electrode catheter revealed a fractionated electrogram that was the first site of cycle length change. Unfortunately, adequate capture could not be obtained despite pacing at maximal outputs from either electrode pair 17 and 18 of the 20-electrode reference catheter or an ablation catheter placed at the same fluoroscopic site. In addition, despite maximal gains, low amplitude electrograms could not be recorded with the

The authors report no conflicts of interest for the published content. Manuscript received January 23, 2012, final version accepted February 13, 2012.

Address correspondence to: Fred M. Kusumoto, MD, Electrophysiology and Pacing Service, Division of Cardiovascular Disease, Mayo Clinic, 4500 San Pablo Ave, Jacksonville, FL 32224. E-mail: Kusumoto.fred@mayo.edu

RAO

LAO

Figure 1: (a) Electrograms obtained from a 64-electrode basket catheter placed in the posterior portion of the left atrium. (b) Fluoroscopic images of the catheter positions in the left anterior oblique (LAO) and right anterior oblique (RAO) projections. The eight individual splines (A–H) of the basket catheter are identified by the location of a longer marker electrode (at the proximal end of the catheter in spline A, at the terminal portion of the catheter in spline G, and no marker in spline H); the course of the A spline is outlined by the small arrows. Changes in cycle length at the most distal electrodes of spline A located at the posterior roof of the left atrium near the right superior pulmonary vein precede changes in cycle length in electrograms recorded from other sites within the atria. The change in cycle length is completely accounted by changes in the conduction interval from electrodes F1,2 to the first and second electrode pairs in spline A (dashed line and arrows: 90 ms and 150 ms). CS: coronary sinus.

Figure 2: The 64-electrode basket catheter has been removed and a 20-electrode catheter has been placed in the posterior left atrium. An ablation catheter has been placed at the electrode pair 17,18 (matching catheter artifact recorded on both the distal ablation and the left atrial 17,18 electrodes (asterisk)). Despite increasing the gain, only small signals are recorded on the ablation catheter and capture cannot be achieved despite maximum outputs. Application of radiofrequency energy leads to termination of tachycardia and restoration of sinus rhythm after 10 s.

large tip (8 mm) ablation catheter. However, radiofrequency ablation (temperatures ranging from 55 to 60°C) at this site terminated the tachycardia after 10 s without any preceding cycle length prolongation (**Figure 2**). After this single ablation, no tachycardia could be induced despite aggressive atrial pacing protocols. She has been arrhythmia free on follow-up after 6 months.

Commentary

Atrial tachycardia after ablation for persistent atrial fibrillation can occur in over 50% of patients depending on the center and technique used.¹ Macrore-entrant tachycardias account for approximately 75% of atrial tachycardias, and the remaining 25% are due to microre-entry and automaticity.¹ Atrial tachycardias with varying

cycle lengths are more commonly associated with focal mechanisms of tachycardia due to automaticity or localized re-entry, although perimitral annular flutter with two cycle lengths has been described.¹⁻³ There are multiple possible mechanisms for atrial tachycardias with variable cycle lengths, including re-entry with variable conduction through a single or multiple gaps or automaticity from two separate foci. In this case the varying cycle lengths of the atrial flutter appeared to be due to alternating conduction times through a single gap located on the roof of the left atrium near the right superior pulmonary vein. This is supported by the observation of split potentials on either side of the gap, the presence of constant and progressive fusion with pacing, and the termination of tachycardia within 10 s with a single lesion. Dofetilide may have enhanced the likelihood of conduction delay through the gap and

facilitated development of such an alternating conduction. One prior study found that stable atrial tachycardia developed in 5 of 66 patients (11.7%) with left atrial tachycardia after ablation for atrial fibrillation. Entrainment mapping was successful in only two of five patients and mapping was guided by identifying areas of fractionated electrograms.⁵

Mapping of atrial flutters can be challenging but generally relies on identifying a critical isthmus using techniques such as entrainment mapping.⁴ Unfortunately, entrainment responses can be difficult to interpret in the setting of varying cycle lengths, are not interpretable if capture cannot be achieved, and, finally, may terminate the tachycardia. In this case, careful analysis of cycle length changes was used to delineate the re-entrant circuit and identify an ablation target. A similar strategy has been used to identify the critical circuit component in bundle branch re-entry.⁶ In this seminal study, the circuit for bundle branch re-entry was delineated by noticing that changes in the interval between His deflections preceded changes in the interval between ventricular signals and a constant interval between the His deflection and the QRS.⁶ Similarly, in this case, changes in the interval between electrograms recorded on the roof of the left atrium preceded changes in the atrial electrograms in the rest of the atrium, and the interval between electrograms recorded from the roof of the left atrium to the rest of the atrium remained constant. The varying cycle length was dependent on conduction changes in a small area of atrial tissue and the critical isthmus was identified by locating the site characterized with the earliest change in atrial electrogram cycle length. The

multi-electrode basket catheter was particularly helpful in this case since it allowed simultaneous recording of multiple sites from the posterior left atrium.

Unusual atrial tachycardias can develop after radio-frequency catheter ablation, particularly with the concomitant use of antiarrhythmic medications. Although entrainment mapping can be difficult to interpret in patients with atrial tachycardias with varying cycle lengths, evaluating the earliest site of cycle length changes may provide an alternative method for identifying an appropriate site for ablation.

References

1. Morady F, Oral H, Chugh A. Diagnosis and ablation of atypical atrial tachycardia and flutter complicating atrial fibrillation ablation. *Heart Rhythm* 2009; 6(8 Suppl):S29–32.
2. Jaïs P, Matsuo S, Knecht S, et al. A deductive mapping strategy for atrial tachycardia following atrial fibrillation ablation: importance of localized reentry. *J Cardiovasc Electrophysiol* 2009; 20:480–491.
3. O'Neill MD, Hocini M, Matsuo S, Haïssaguerre M. Twin perimitral atrial flutters with alternating cycle lengths. *J Cardiovasc Electrophysiol* 2007; 18:455–456.
4. Waldo AL. From bedside to bench: entrainment and other stories. *Heart Rhythm* 2004; 1:94–106.
5. Mikhaylov E, Szili-Torok T, Abramov M, Lebedev D. Ablation of left atrial tachycardia with cycle length alternans after atrial fibrillation ablation: Significance of fractionated electrogram mapping. *J Electrocardiol* 2011; 44:164–170.
6. Caceres J, Jazayeri M, McKinnie J, et al. Sustained bundle branch reentry as a mechanism of clinical tachycardia. *Circulation* 1989; 79:256–270.