A postsurgery atrial tachycardia with alternating cycle length: The possible circuits revealed by high-resolution mapping

Dongchen Zhou, MD,* Wei Hu, MD,† Gang Yang, MD,‡ Hongwu Chen, MD,† Biqi Zhang, MD,* Jie Han, MD,* Jian Yang, MD,* Li Li, BS,‡ Liangrong Zheng, MD*

From *The First Affiliated Hospital of Zhejiang University, Hangzhou, China, †The First Affiliated Hospital of Nanjing Medical University, Nanjing, China, and ‡Boston Scientific China, Shanghai, China.

Introduction
Alternating cycle length (CL) can be seen in some regular tachycardias. Previous case reports have described different mechanisms in atrioventricular reentrant tachycardia, atrioventricular nodal reentrant tachycardia, and atrial tachycardia (AT) after atrial fibrillation ablation.1–7 However, AT after surgery with alternating CLs was seldom reported.

Case report
A 49-year-old female patient with a history of surgical repair for atrial septal defect and tricuspid valvuloplasty presented with typical atrial flutter and was referred for electrophysiology study. High-resolution mapping with the Rhythmia three-dimensional electroanatomic mapping system (Boston Scientific, Marlborough, MA) was performed in the right atrium. The initial CL was 240 ms. The activation map revealed the counterclockwise mechanism, which was also proven by entrainments (Supplemental Figure 1A). Two lines of block and 1 low-voltage isthmus were identified during tachycardia: crista terminalis, right atrial (RA) free wall incision, and septal patch (Supplemental Figure 1B, 1C). Linear ablation was applied on the cavotricuspid isthmus and terminated the tachycardia. Bidirectional block of the cavotricuspid isthmus was confirmed by verify mapping (v-Map) during coronary sinus ostium and low RA pacing.

AT with alternating CLs of 233 ms (CL 1) and 273 ms (CL 2) was induced by burst pacing (Figure 1). Then 2 activation mappings under the different CLs were performed, respectively. Activation maps and propagations showed the possible reentrant circuits and blocked lines under the 2 CLs (Figure 2 and Videos 1 and 2). There were 2 conduction isthmuses after the common isthmus. The activation wavefront could go through both isthmuses in the CL 1 map. When isthmus 1 was in functional block in the CL 2 map, the wavefront conducted via isthmus 2 only, which was more inferior. This made the reentrant circuit longer in the CL 2 map than in the CL 1 map. The local activation sequences and signals at isthmus 1 alternating with double and single potentials also suggested the conduction there was intermittent (Figure 3).

The ablation strategy was to close the common isthmus. A single ablation delivery terminated the AT (Supplemental Figure 2). More ablation was applied to close the gap between the 2 blocked lines.

At 3-month follow-up, the patient remained in sinus rhythm with no antiarrhythmic medications.

Discussion
Entertainments to confirm the reentry were not delivered owing to the alternating CL during the procedure.

KEY TEACHING POINTS
- Tachycardia with alternating cycle length usually has different reentrant circuits. It should be mapped under different cycle lengths, respectively.
- Entrainments remain important to confirm the reentrant mechanism even with alternating cycle length.
- High-resolution mapping is useful to identify the critical isthmus and facilitate the ablation successfully with limited radiofrequency lesion.

KEYWORDS
Ablation; Alternating cycle length; Atrial tachycardia; High-resolution mapping; Postsurgery; Rhythmia (Heart Rhythm Case Reports 2020;6:297–299)

Li Li is a Boston Scientific employee. The other authors have no conflicts of interest.

Address reprint requests and correspondence: Dr Liangrong Zheng, Cardiology Department, The First Affiliated Hospital, College of Medicine, Zhejiang University, 79, Qingchun Rd, Hangzhou, Zhejiang, China 310003. E-mail address: 1191066@zju.edu.cn.

https://doi.org/10.1016/j.hrcr.2019.05.005
Although abnormal automaticity and triggered activity from the critical isthmus were not excluded by pacing, the possible mechanism remained to be macroreentry. John and colleagues\textsuperscript{5} showed the significance of pacing study to confirm the mechanism of AT even with alternating CL. Besides measuring postpacing interval, comparing the interval from stimulus to the surface P wave (S-P) or to a stable intracardiac A wave (S-A) with the local electrogram to the P or A wave (E-P or E-A) is another available method.\textsuperscript{5}

Nakashima and colleagues\textsuperscript{6} reported a case of atrial flutter with 2 different CLs. Electrophysiological study suggested that 2 pathways with differing conduction times existed.\textsuperscript{6} O’Neill and colleagues\textsuperscript{7} reported another case post persistent atrial fibrillation ablation with alternating CLs. The possible reentry was around the mitral annulus, with alternating conduction across 2 gaps within the mitral isthmus with differing conduction velocities and/ or refractory periods.\textsuperscript{7} Recently, Frontera and colleagues\textsuperscript{8} have characterized that reentrant ATs have multiple sequential isthmuses of slow conduction, serving as sequential isthmuses rather than a single isthmus. This case is an example where the tachycardia uses parallel isthmuses alternately after passing through a common isthmus. The intermittent isthmus with 1:1 conduction may be caused by its unmatched effective refractory period and CL. In this case, the effective refractory period of the myocardium at the intermittent isthmus (isthmus 1) should be longer than CL 1 (233 ms), but shorter than CL 1 + CL 2 (506 ms).

The conventional strategy for lateral RA reentrant tachycardia is to connect the line of block to the inferior vena cava, the tricuspid annulus, or, rarely, the superior vena cava, which needs more linear ablation and may interfere with the normal sinus activation. In this case, the high-resolution mapping clearly identified the critical isthmus and facilitated the ablation successfully with limited radiofrequency lesion.

![Figure 1](image1.png)  
**Figure 1**  
Coronary sinus (CS) signals and cycle length (CL) graph of atrial tachycardia. The CLs were alternating between 233 ms and 273 ms. In the CL 1 map, the beat acceptance criteria CL was set as 233 ± 5 ms (green band).

![Figure 2](image2.png)  
**Figure 2**  
(A and B) Right posterior oblique views of cycle length (CL) 1 and CL 2 activation maps (A and B). Activation patterns showed the difference of the circuits and lines of block (white arrows and lines). Dotted red circles indicate the 2 isthmuses after the common isthmus. White lines indicate the anatomical block (incisional line). White dotted lines indicate the functional block (crista terminalis [CT] and isthmus 1).
Figure 3  Local activation sequences of the isthmuses of cycle length (CL) 1 map and CL 2 map. The signals at isthmus 1 alternating with double and single potentials (the roving probes and red arrows) indicated the intermittent conduction there. A: Local activation time (LAT) at position 2 and position 3 were similar in CL 1 map. B: LAT was significantly later at position 3 than at position 2 in CL 2 map. That also suggested the block at isthmus 1.

Appendix
Supplementary data
Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2019.05.005.

References
1. Lim PB, Wright IJ, Salukhe TV, Lefroy DC. Narrow complex tachycardia with alternating cycle length: what is the mechanism? J Cardiovasc Electrophysiol 2011;22:1399–1401.
2. Amasyali B, Kose S, Celik T. Atrioventricular nodal re-entrant tachycardia with QRS voltage and cycle length alternation and aberrant conduction due to two distinct antegrade slow pathways. Europace 2006;8:134–137.
3. Buch E, Tung R, Shehata M, Shivkumar K. Alternating cycle length during supra-ventricular tachycardia: what is the mechanism? J Cardiovasc Electrophysiol 2009;20:1071–1073.
4. Arias MA, Pachol A, Colchero T, Castellanos E. A long-RP narrow QRS complex tachycardia with alternating cycle length: what is the mechanism? J Cardiovasc Electrophysiol 2010;21:588–589.
5. John WS, Win-Kuang S, Komandoor SS. Atrial tachycardia with fluctuating cycle length post multiple atrial fibrillation ablations. Available at https://www.acc.org/education-and-meetings/patient-case-quizzes/atrial-tachycardia-with-fluctuating-cycle-length-post-multiple-atrial-fibrillation-ablations. Accessed August 5, 2015.
6. Nakashima D, Kojima S, Nakabo A, et al. A atrial flutter consisted of two different conduction pathways. Int J Cardiol 2008;123:e51–e53.
7. O’Neill MD, Hocini M, Matsuo S, Haissaguerre M. Twin perimital atrial flutters with alternating cycle lengths. J Cardiovasc Electrophysiol 2007;18:455–456.
8. Frontera A, Mahajan R, Dallet C, et al. Characterizing localized reentry with high-resolution mapping: Evidence for multiple slow conducting isthmuses within the circuit. Heart Rhythm 2019;16:679–685.