

Title: An irregularly irregular supraventricular tachycardia: What is the mechanism?

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Case Presentation

A 48-year-old woman visited an outpatient clinic of a local physician because of recurrent palpitation. Narrow QRS complex tachycardias with cycle length alternation were documented in a self-measured portable electrocardiogram (Figure 1). The cycle length patterns were almost divided into two groups; shorter cycle length (275-302ms blue font) and longer cycle length (313-352ms green font). She was referred to our hospital for catheter ablation. A 12-lead electrocardiogram showed no delta wave. Transthoracic echocardiography revealed no structural heart disease. She underwent an electrophysiological study. Decapolar electrode catheters were placed at the His region and in the coronary sinus (CS). Quadripolar electrode catheters were placed at the high right atrium and right ventricular apex (RVA). The baseline A-H interval was 72 ms, and H-V interval was 50ms without preexcitation. Ventricular pacing revealed eccentric atrial activation with the earliest atrial activation site (EAAS) at 3 o'clock on mitral annulus. Supraventricular tachycardia (SVT) was induced by programmed single ventricular extra stimulation (VES) without change of ventriculoatrial (VA) interval. And premature atrial

complex also induced the SVT with AV jump. The induced SVT was short RP tachycardia with alternating both VA interval and cycle length (Figure 2). Atrial activation sequences were identical regardless of VA intervals. What is the mechanism?

Commentary

AH intervals also varied depending on preceding VA intervals. Short VA intervals preceded long AH intervals, and long VA intervals preceded short AH intervals, indicating antegrade conductions were through slow pathway (SP) and fast pathway (FP), respectively. Because the prolongation of AH intervals was greater than shortening of VA intervals, shorter VA intervals were paradoxically associated with longer cycle lengths. Local VA intervals at the EAAS were only two patterns, 60ms and 98ms regardless of preceding VV intervals, suggesting that retrograde conductions were through two accessory pathway (AP) with different conduction times (short AP and long AP).

We performed pacing maneuvers during SVT with long VA interval, because SVT with long VA interval was relatively stable. VES from RVA at the timing of His refractory did not reset SVT, but premature ventricular complex from left ventricle terminated SVT without atrial capture, showing that atrial tachycardia (AT) was unlikely. Ventricular overdrive pacing from RVA showed V-A-V pattern with a short corrected post-pacing

interval minus tachycardia cycle length of 86ms, indicating that AT and atrioventricular reentrant tachycardia (AVNRT) were both unlikely (Figure 3)¹. From these findings, SVT with long VA interval was diagnosed as FP/long AP orthodromic atrioventricular reciprocating tachycardia (AVRT). Accordingly, the irregular SVT presumably consisted of FP/long AP and SP/short AP orthodromic AVRT.

We placed ablation catheter on the EAAS at 3 o'clock of mitral annulus during irregular SVT. Although AP potential was not recorded on the ablation catheter electrodes, the SVT terminated 2232ms after starting radiofrequency ablation. After the ablation, we confirmed the disappearance of retrograde AP conduction by VA dissociation after adenosine triphosphate administration during ventricular pacing, showing two APs were simultaneously eliminated. Thereafter, no tachycardia was induced by programmed stimulation under isoproterenol infusion. The patient has been free from any symptoms for 12 months after the ablation procedure.

Although AVNRT and orthodromic AVRT generally have stable tachycardia cycle lengths, AVNRT often exhibits irregular tachycardia due to decremental conduction property or multiple atrioventricular nodal pathways². The cycle length alternation has been also reported in orthodromic AVRT with antegrade conduction alternating between fast and slow pathways³. In addition, orthodromic AVRT with alternating both cycle

length and atrial activation sequence has been reported because of alternating retrograde conduction between two concealed left-sided APs⁴. However, in our case, atrial activation sequences were identical regardless of VA intervals. Another paper reported that cycle length alternation during orthodromic AVRT was caused by conduction delay at the left atrium-CS musculature connection⁵, but in our case, atrial activation potentials at CS electrodes were not separated into left atrial and CS musculature potentials. Speculating on the mechanism of two retrograde conduction patterns with same atrial activation sequence but different conduction time, the following possibilities were considered; two very closely spaced APs or one AP with longitudinal dissociation.

Furthermore, when retrograde conduction was through short AP, FP presumably entered effective refractory period and antegrade conduction changed FP to SP. The prolongation of antegrade conduction exceeded the shortening of retrograde conduction, resulting in a paradoxical prolongation of cycle length at short VA intervals.

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Conflict of Interest Statement

The authors declared that no competing interests exist.

Declarations

Written informed consent was obtained from the patient.

References

1. Gonzalez-Torrecilla E, Arenal A, Atienza F, et al. First postpacing interval after tachycardia entrainment with correction for atrioventricular node delay: a simple maneuver for differential diagnosis of atrioventricular nodal reentrant tachycardias versus orthodromic reciprocating tachycardias. *Heart Rhythm*. 2006;3(6):674-679.
2. Otomo K, Nagata Y, Uno K, Fujiwara H, Iesaka Y. Irregular atypical atrioventricular nodal reentrant tachycardia: incidence, electrophysiological characteristics, and effects of slow pathway ablation. *Heart Rhythm*. 2007;4(12):1507-1522.
3. Kara M, Korkmaz A, Karimli E, et al. Tachycardia cycle length alternans during a narrow QRS complex tachycardia with eccentric retrograde atrial activation sequence: What is the mechanism? *J Arrhythm*. 2020;36(1):209-210.
4. Nakashima T, Nagase M, Shibahara T, et al. Supraventricular tachycardia with alternating eccentric atrial activation: What is the mechanism? *J Cardiovasc Electrophysiol*. 2022;33(3):548-550.
5. Nakatani Y, Mizumaki K, Sakamoto T, Kinugawa K. Cycle Length Alternation during Atrioventricular Reentrant Tachycardia: What Is the Mechanism? *Pacing Clin Electrophysiol*. 2017;40(4):434-437.

Figure legends

Figure 1. Narrow QRS complex tachycardias with cycle length alternation documented in self-measured portable electrocardiogram

The cycle length patterns were almost divided into two groups; shorter cycle length (blue font) and longer cycle length (green font).

Figure 2. Induced irregular SVT

SVT was short RP tachycardia with alternating both VA interval and cycle length. Atrial activation sequences were identical regardless of VA intervals.

SVT, supraventricular tachycardia; VA, ventriculoatrial.

Figure 3. Ventricular overdrive pacing from RVA in SVT with long VA interval

After cessation of ventricular overdrive pacing with a PCL of 360ms, SVT resumed with V-A-V pattern. Corrected PPI-TCL was $576-420-70=86\text{ms}$, shorter than 115ms.

RVA, right ventricle apex; SVT, supraventricular tachycardia; VA, ventriculoatrial; PCL, pacing cycle length; PPI, post pacing interval; TCL, total cycle length.



