A Case Series of Very Slow Atrioventricular Nodal Reentrant Tachycardia Resembling Junctional Tachycardia

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Abstract

Introduction: The surface EKG of typical atrioventricular nodal reentrant tachycardia (AVNRT) shows simultaneous ventricular-atrial (RP) activation with pseudo R' in V1 and typical heart rates ranging from 150-220/min. Slower rates are suspicious for junctional tachycardia (JT). However, occasionally we encounter typical AVNRT with slow ventricular rates. We describe a series of typical AVNRT cases with heart rates under 110/min. **Methods:** A total of 1972 patients with AVNRT who underwent slow pathway ablation were analyzed. Typical AVNRT was diagnosed when; 1) evidence of dual atrioventricular nodal conduction, 2) tachycardia initiation by atrial drive train with A-H-A response, 3) septal ventriculoatrial (VA) time $<$ 70 ms, and 4) ventricular-atrial-ventricular (V-A-V) response to ventricular overdrive (VOD) pacing with post pacing interval-tachycardia cycle length (PPI-TCL) $>$ 115ms. JT was excluded by either termination or advancement of tachycardia by atrial extrastimuli (AES) or atrial overdrive (AOD) pacing. **Results:** We found 11 patients (Age 20-78 years old, 6 female) who met the above-mentioned criteria. The TCL ranged from 560ms to 782ms. Except for one patient showing tachycardia termination, all patients demonstrated a V-A-V response and PPI-TCL over 115ms with VOD. AES or AOD pacing successfully excluded JT by either advancing the tachycardia in 10 patients or by tachycardia termination in one patient. Slow pathway was successfully ablated, and tachycardia was not inducible in all patients. **Conclusions:** This case series describes patients with typical AVNRT with slow ventricular rate (less than 110/min) who may mimic JT. We emphasize the importance of using pacing maneuvers to exclude JT.

A Case Series of Very Slow Atrioventricular Nodal Reentrant Tachycardia Resembling Junctional Tachycardia

Short title: Very Slow Typical Atrioventricular Nodal Reentrant Tachycardia

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Methods: A total of 1972 patients with AVNRT who underwent slow pathway ablation were analyzed. Typical AVNRT was diagnosed when; 1) evidence of dual atrioventricular nodal conduction, 2) tachycardia initiation by atrial drive train with A-H-A response, 3) septal ventriculoatrial (VA) time $<$ 70 ms, and 4) ventricular-atrial-ventricular (V-A-V) response to ventricular overdrive (VOD) pacing with post pacing interval-tachycardia cycle length (PPI-TCL) $>$ 115ms. JT was excluded by either termination or advancement of tachycardia by atrial extrastimuli (AES) or atrial overdrive (AOD) pacing.

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Conclusions: This case series describes patients with typical AVNRT with slow ventricular rate (less than 110/min) who may mimic JT. We emphasize the importance of using pacing maneuvers to exclude JT.

Keywords : Typical AVNRT, Junctional tachycardia, Slow ventricular rate

Abbreviations

AV: atrioventricular

AVNRT: atrioventricular nodal reentrant tachycardia

JT: junctional tachycardia

EPS: electrophysiological study

TCL: tachycardia cycle length

AH: atrial-His

HV: His-ventricular

VOD: ventricular overdrive pacing

AOD: atrial overdrive pacing

AES: atrial extrastimululs

PPI: post pacing interval

TCL: tachycardia cycle length

Introduction

Dual atrioventricular (AV) nodal physiology is a common finding during an electrophysiologic study. This finding provides a substrate for the common form of atrioventricular nodal reentrant tachycardia (AVNRT)[1].

The typical form of AVNRT (slow-fast type) shows a short R-P or a simultaneous R-P during tachycardia with heart rates usually ranging from 150/min to 220/min[2]. Pseudo R' in V1 is a common feature. However, if the heart rate during tachycardia is relatively slow, junctional tachycardia (JT) emerges as part of the differential diagnosis. Notably, while catheter ablation of AVNRT has been reported with a very high success rate and low incidence of heart block[2], catheter ablation of JT has a lower success rate and higher rates of complete heart block. Therefore, during the electrophysiological study, using maneuvers such as atrial overdrive pacing (AOD) and atrial extrastimulus (AES)[3,4] to differentiate AVNRT and JT is important.

In this study, we reported a series of patients with slow, symptomatic typical AVNRT below 110 bpm resembling JT, which were successfully diagnosed and ablated.

Methods

Study population

We retrospectively analyzed 1972 patients (1569 patients from Cleveland Clinic, 403 patients from the University of California, San Francisco) who underwent catheter ablation of AVNRT ablation between Jan 2013 to Sep 2021.

Electrophysiologic Study

After giving informed written consent, patients underwent electrophysiologic studies (EPS). Atrial overdrive and extrastimulus were delivered to induce supraventricular tachycardia. Isoproterenol infusion was used to facilitate sustained tachycardia if needed. In order to demonstrate that the mechanism of this tachycardia is the typical slow-fast AVNRT, not automaticity (i.e., JT) or ventricular dependent reentry, AOD, AES, or ventricular overdrive (VOD) pacing were delivered during tachycardia. AVNRT was diagnosed using criteria as follows; 1) evidence of dual AV nodal physiology at the initiation of tachycardia, 2) tachycardia initiation by atrial drive train with A-H-A response, 3) septal ventriculoatrial (VA) time < 70 ms, and 4) ventricular-atrial-ventricular (V-A-V) response to ventricular overdrive (VOD) pacing with post pacing interval minus tachycardia cycle length (PPI-TCL) > 115ms. 5) Demonstration that both the slow pathway (SP) and fast pathway (FP) are capable of conducting faster than the TCL during entrainment. 6) During atrial entrainment via the SP, atrial septal PPI-TCL is less than 50 ms. 7) Advancement or termination of the tachycardia was demonstrated by AOD or AES[3,4]. These maneuvers also serve to exclude concealed nodoventricular or nodofascivular pathways.

From the EPS, the following data were also investigated; tachycardia cycle length (TCL), atrial-His (AH) interval during tachycardia, His-ventricular (HV) interval during tachycardia, AH interval during sinus.

Catheter Ablation

Catheter ablation was performed with a 4 mm tip non-irrigated radiofrequency ablation catheter or a 3.5 mm saline cooled catheter. For temperature-controlled delivery, power was titrated from 30-50 W with a temperature limit of 50° to 60° for a duration of 60-90 seconds to achieve accelerated junctional beats with intact AV and VA conduction. For the saline cooled catheter, power was initiated at 20-25 W and titrated up to 35 W while monitoring accelerated junctional beats. Ablation endpoints were lack of inducibility of AVNRT and no more than single slow-fast AV nodal echo beats with programmed stimulation in either the basal state or during isoproterenol infusion.

Results

We identified 5 patients from Cleveland Clinic and 9 patients from the University of California, San Francisco, who had very slow (110 bpm or less) typical AVNRT. Three additional patients were excluded because they did not undergo AOD or AES pacing maneuvers as noted in the Methods section, although tachycardia was no longer inducible after their slow pathway ablation. Therefore, a total of 11 patients were included in this analysis. Patient characteristics and electrophysiologic study data are shown in **Table 1.** Ages ranged from 20 to 78 years. There were six females and five males. One patient was undergoing a 4th ablation (Case 4), and two patients had their 2nd ablations (Case 7 and 9). All other patients were undergoing their initial

ablation. The tachycardia cycle length ranged from 560ms to 782ms. Septal VA times were all within 70ms. All patients except for one demonstrated V-A-V response by VOD, which showed PPI-TCL over 115ms. VOD reproducibly terminated tachycardia in one patient (Case 8), and thus VOD could not be obtained.

We delivered AOD or AES to distinguish this tachycardia from JT. Advancement of the tachycardia was recognized by overdrive pacing from at least one location of the atrium (usually from the coronary sinus ostium) in 5 patients. Termination of tachycardia was recognized in one patient by overdrive atrial pacing (Case 4). With regards to the response to AES, 6 patients showed an A-H-A response, while one patient (Case 1) showed A-H-H-A response with the advancement of the tachycardia, likely due to a double ventricular response.

All patients underwent successful slow pathway ablation rendering their tachycardia not inducible after ablation.

Patient Example (Case 4)

Figure 1 shows ECGs during sinus (A) and reentrant arrhythmia (B) of a patient example (Case 4) who underwent 3 slow pathway ablations prior to the current study. This patient had been in this incessant arrhythmia shown in panel B after the 3rd ablation. The surface ECG showed a very slow junctional type arrhythmia (HR 75/min), and the patient was significantly symptomatic when in this arrhythmia. The patient was treated as having a junctional arrhythmia, and beta-blocker therapy was prescribed, which did not improve her symptom. Due to the inefficacy of this treatment, the patient was referred for further possible ablation. Intracardiac studies showed simultaneous VA activation with septal VA timing of 59ms. VOD showed V-A-V response with PPI-TCL 177ms **(Figure 2).** AES delivered during the slow pathway refractory period (on time with retrograde fast pathway depolarization) terminated the tachycardia, which proved that slow pathway conduction was part of the tachycardia mechanism **(Figure 3)** . AOD delivered from CS 1-2 successfully entrained the tachycardia. The septal PPI-TCL confirmed a reentrant mechanism **(Figure 4)** . After the successful slow pathway ablation, this tachycardia could never be inducible, and the patient became asymptomatic.

Discussion

The typical form of AVNRT uses the slow pathway as the anterograde limb and the fast pathway as the retrograde limb with perinodal atrial tissue bridging the fast to the slow pathways. The ECG of typical AVNRT shows a short R-P or simultaneous R-P during tachycardia with pseudo R' in V1. However, this finding needs to be differentiated from JT as the ECG of JT may resemble typical AVNRT, especially when the tachycardia is relatively slow. In these tachycardias, a patient may be significantly symptomatic even when in slow heart rate given the simultaneous atrial and ventricular activation, which generates atrial contraction during mitral and tricuspid valves closure resulting in palpitation, heart pounding, fatigue, or poor exercise tolerance.

While the usual heart rates of typical AVNRT during tachycardia range from 150/min to 220/min, some patients present with slow AVNRT if the conduction time of the slow pathway is long and its effective refractory period is short (compared to fast pathway). This type of slow typical AVNRT mimics JT and sometimes may be mistakenly treated as JT as described in Case 4. These slow tachycardias should be distinguished from JT with appropriate pacing maneuvers so that appropriate ablation treatment can be performed.

Conclusion

We report a case series of patients with slow typical AVNRT (less than 110/min), which may mimic JT. Comprehensive electrophysiologic studies are necessary to exclude JT and direct appropriate ablation treatment.

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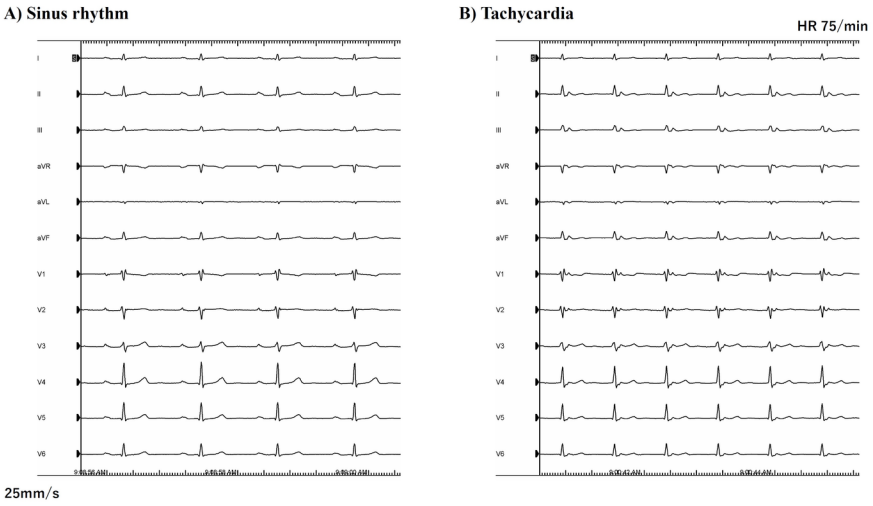
Figure Legends

Figure 1. Sinus rhythm and tachycardia ECG

Panel A: Twelve-lead surface ECG of sinus rhythm. Note the prolonged PR interval of 290ms consistent with poor or lack of anterograde conduction via the fast pathway. This likely explains the incessant nature of this patient's frequent tachycardia.



Panel B: Twelve-lead surface ECG of the slow tachycardia. Pseudo R' can be recognized in V1. Time lines for both panels are 400 ms per large division.

Figure 2. Response during ventricular overdrive pacing

Overdrive pacing from right ventricular apex (RVa 1-2) during tachycardia resulted in a post pacing V-A-V response and a long PPI-TCL of 177ms. This maneuver excludes a ventricular nodal/Hisian mechanism. It also demonstrates that the retrograde fast pathway is capable of conducting faster than the TCL.

Intracardiac electrograms as follows: HRA= high right atrium, CS= coronary sinus, HIS= His bundle, RVa= right ventricular apex.

Figure 3. Atrial extrastimulus during tachycardia

AES delivered at the high right atrium (HRA 1-2) activating the septal regions during retrograde fast pathway conduction (i.e. collision with the retrograde fast pathway impulse) caused block in the slow pathway terminating the tachycardia. This termination demonstrates that the slow pathway is a part of the reentrant circuit.

AES= atrial extrastimuli

Figure 4.

AOD from CS 1-2 advanced the tachycardia with an A-H-A response. AOD was delivered just after the slow pathway refractory so that it anterogradely captured and advanced the tachycardia via the slow pathway. Note that the PPI at the proximal CS electrograms (CS 9,10) as a proxy for septal activation had a PPI-TCL

of 30 or 40 ms depending on how one measures the TCL. This value confirmed that the atrial septum near the tricuspid annulus was part of the reentrant circuit.

AOD: atrial overdrive pacing

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`image5.emf` available at https://authorea.com/users/455630/articles/552928-a-case-series-of-very-slow-atrioventricular-nodal-reentrant-tachycardia-resembling-junctional-tachycardia

Table 1

TCL=tachycardia cycle length, VOD=ventricular overdrive, PPI-TCL=post pacing interval minus tachycardia cycle length, SA-VA=ventricular stimulus to atrial interval minus ventricular atrial interval during tachycardia, AOD=atrial overdrive, AES=atrial extrastimulus.