Orthodromic Reciprocating Tachycardia Relying on Aberrant Conduction: Need for a Lager Circuit

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Abstract

Background Aberrant conduction during orthodromic reciprocating tachycardia (ORT) can prolong the ventriculo-atrial conduction time, which is found essential for the reentry in certain situations. *Materials and Methods* We searched for ORT cases relying on aberrancy from 220 cases in our center. *Results* 3 patients showed the phenomenon of aberrancy-dependent ORT. All accessory pathways were located at anterolateral regions of atrioventricular annulus. None of them had baseline bundle branch block. Creating functional bundle branch block was necessary to induce the tachycardias. In 2 cases, termination directly associated with resolution of aberration was observed. While in the other case, reentry required both interventricular block and slow pathway conduction. *Conclusions* We conclude that extra transseptal time caused by aberrancy can be an integral part of ORT, which can explain the infrequent or late onset and unsustainable episodes of ORT in certain patients and is useful in understanding the circuit and localizing the pathway.

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Abstract

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Key words: orthodromic reciprocating tachycardia, aberrancy, bundle branch block, accessory pathway, supraventricular tachycardia

Introduction

During orthodromic reciprocating tachycardia (ORT), or atrioventricular reentrant tachycardia, functional bundle branch block (BBB) can be present when wavefront encroaches on the refractory period of His-Purkinje system. Ventriculo-atrial conduction time is shortened when bundle branch conduction is improved during ORT utilizing ipsilateral concealed accessory pathway (AP) [1-3]. However, this may exactly advance wavefront to the refractory period of the circuit components which results in tachycardia termination. Here we describe a group of patients sharing the phenomenon of ORTs relying on aberrant conduction based on various mechanisms.

Materials and Methods

ORTs undergoing electrophysiology (EP) study in our center between January 2017 and January 2022 were reviewed. ORT relying on aberrancy were selected using the following criteria: (1) Multiple episodes of ORT with aberrant conduction in ECG from emergency room or EP study; (2) No baseline BBB during sinus rhythm; (3) Absence of narrow QRS form during tachycardia unless isoproterenol used; (4) Restoration of bundle branch conduction giving rise to tachycardia termination or circuit alteration. ECGs and intracardiac tracings during study were carefully examined. The study was approved by the ethics committee of Huashan Hospital Fudan University.

Results

Baseline information

Among 220 cases of ORT, 94 (42.7%) cases showed BBB during tachycardia, from which 3 (1.4%) patients fulfilled the criteria above.

Case 1

A 56-year-old male with mild preexcitation was referred for EP study who had several episodes of palpitation recently. All recorded ECGs during tachycardia were in left bundle branch block type. Maximal preexcitation pattern was consistent with a left AP. Retrograde conduction was over distal coronary sinus (CS) when pacing from right ventricle (RV). Tachycardia was induced by an atrial extrastimulus blocked in the AP, conducting over the AV node and causing left bundle branch block.

A late-delivered premature ventricular contraction (PVC) was able to advance the next A and reset the tachycardia, which was diagnostic for ORT with aberrancy. In the meantime, left bundle branch conduction was restored which narrowed the next QRS complex. Tachycardia was then terminated by the advanced wavefront reaching the ventricular insertion site of AP which was refractory (Figure 1). Mapping of the AP was performed using transseptal approach during RV pacing. The earliest atrial activation site was located at anterolateral mitral annulus (MA) with a sharp potential, where radiofrequency application successfully blocked the AP. The patient has been free from the tachycardia for 1 year.

Case 2

A 64-year-old gentleman presented with very frequent tachycardia which always terminated spontaneously within minutes. The only ECG from emergency room showed tachycardia with left bundle branch block type. His tortuous femoral veins made it difficult for catheterization, therefore only an RV catheter was inserted with CS catheter placed from jugular vein for EP study. The earliest atrial activation site was CS3-4 during RV pacing, indicating a left lateral AP. Atrial pacing and extrastimulus showed no preexcitation or intraventricular block.

The clinical tachycardia could only be induced by RV extrastimulus with isoproterenol, which could not sustain for more than 10 beats, compatible with ORT with aberrancy. Termination of the tachycardia was always preceded by a narrow QRS complex, with the V and subsequent A at MA advanced, suggesting

anterograde block in the AV junction (Figure 2). The pathway was ablated at anterolateral MA with retrograde approach, after which no tachycardia could be induced. The patient has been free from the symptom for more than 3 years.

Case 3

A 24-year-old female having manifest preexcitation presented with frequent but short episodes of palpitation without ECG documentation. Extrastimuli from high right atrium (HRA) revealed maximal preexcitation suggesting a right anterolateral pathway, and dual AV nodal phenomenon. Retrograde conduction over the AP was also confirmed. However, the tachycardia could not be initiated from either RV or HRA. But stimulus from left atrium was able to readily induce the tachycardia by conducting solely over the slow pathway of AV node and causing concomitant functional right bundle branch block (RBBB), with following beats showing A-H interval identical to the last paced beat, indicating perpetuated slow pathway conduction (Figure 3, left panel). His-refractory PVC during tachycardia confirmed the mechanism of ORT.

When isoproterenol (8mcg/min) was given during tachycardia , fast pathway and right bundle branch conduction were both improved, followed by a paradoxically longer tachycardia cycle length (TCL) owing to marked AV prolongation (Figure 3, right panel), indicating anterograde limb again switched to the slow pathway. The narrow tachycardia was neither sustainable nor re-inducible when high-dose isoproterenol was discontinued. The pathway was eliminated at 11 o'clock on tricuspid annulus with the help of a deflectable sheath. After AP ablation, slow pathway conduction remained without echo beat or inducible atrioventricular nodal reentrant tachycardia. The patient had no symptoms at 2-year follow-up.

Discussion

Major findings

In this report, we demonstrate a phenomenon of aberrancy being essential for certain ORT cases. The major findings included:

1. In the cases of ORTs relying on aberrancy, all APs are anterolateral pathways located on the same side of BBB.
2. Clinical tachycardia episodes were often short in time.
3. Stimulation during single bundle branch refractoriness is required for inducing tachycardia.
4. Resolution of aberration was followed by the shortening of subsequent VA interval which was responsible for tachycardia cessation.
5. The block site of tachycardia after BBB resolution can be AP or AV node.

Basic Mechanism for Functional BBB-dependent ORT

When aberration is present during ORTs mediated by ipsilateral APs, impulse travels down the contralateral bundle branch and lengthens VA time[1-3]. Meanwhile, retrograde penetration into the blocked bundle branch subsequent to transeptal conduction perpetuates aberration during tachycardia, which can diminish spontaneously or be restored by a ventricular extrastimulus peeling back the refractoriness of the bundle[4].

As a macro-reentrant tachycardia, ORT can be theoretically non-inducible in patients with APs if the conduction properties of AP or AV node do not fulfill the prerequisite of reentry e.g., small circuit, long refractory period, or rapid conduction. However, in the setting of aberrancy, an extra transseptal conduction time of approximately 40ms[2] is added to VA conduction which helps the wavefront avoid the refractoriness of the circuit components. Conversely, the restoration of BBB can shorten intraventricular time and terminate tachycardia.

In our report, all APs were from lateral regions of AV rings, which provided more significant increase in TCL when BBB occurs, compared to septal pathways. To induce tachycardia in this setting, anterograde conduction should meet multiple requirements including (1) AP was refractory; (2) AV node was excitable; and (3) the ipsilateral bundle branch was unexcitable, which can explain the short clinical episodes and late onset possibly associated with age-related infra-His conduction disturbance (case 1 and 2). Therefore, timing

and site of pacing are important, and the refractory period of AV node, AP and His-Purkinje system should be carefully measured.

EP Findings Supporting the Need for Aberrancy

When BBB was improved, advanced wavefront encountered refractory period of AP or normal AV conduction system via different mechanism which validated the need for aberration (Central illustration).

In case 1, a His-refractory PVC advanced the subsequent A and His through the AP. Meanwhile, it peeled back the refractoriness of the left bundle by "pre-exciting" it from retrograde direction, which narrowed the next QRS. The 2 effects above advanced the ventricular signal at anterolateral mitral annulus (V_{CS1-2}) by 60msec, which was in the refractory period of AP. Case 2 had similar mechanism as case 1, while resolution of block was spontaneous. The local V and following A on the left side were advanced in this beat which made the wavefront reaching the atrioventricular junction (could be AV node or His-Purkinje system) during refractoriness.

In case 3, stable tachycardia could only be induced when RBBB was created together with slow pathway conduction. With isoproterenol given, slow pathway was replaced by fast pathway to participate in reentry, followed by improvement of aberration resulting in premature depolarization of AP, which afterwards advanced the input into AV junction and again blocked the fast pathway. It suggested both infra-His block and slow pathway conduction contributed to maintaining reentrant activation. Interestingly, the narrow QRS tachycardia had a longer TCL than the wide complex owing to marked increase in AV interval, demonstrating a reversed finding to the "Coumel's law"[5].

Proportion of ORTs Relying on Aberrancy

From our 95 cases of ORT with aberrancy, only 3 showed solid evidence proving BBB was indispensable. The others included ORTs with pre-existing BBB, concomitant wide and narrow QRS, and those only showing wide QRS. In the latter situation, sensed extrastimuli with different prematurity have been attempted in straightforward cases but failed to reactivate the blocked bundle. Therefore, it remains unknown whether those cases were relying on aberration or not. Additionally, the conduction velocity and refractory period of AV node and AP can be altered by medications and autonomic nerve activity, which may influence the dependence of aberrancy during EP study.

Limitations

Number of cases is limited due to rare presentation of the phenomenon. Episodes of tachycardia were too short for multiple differential diagnostic maneuvers in case 2.

Conclusions

In ORTs utilizing anterolateral APs, extra transseptal conduction time caused by aberrancy can be an integral part of the circuit, which enables reentrant activation by enlarging the circuit. It can explain the infrequent or late onset and unsustainable episodes of ORT in certain patients with APs, which can also be regarded as a useful tool in understanding the mechanism and localizing the AP.

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Figure legends

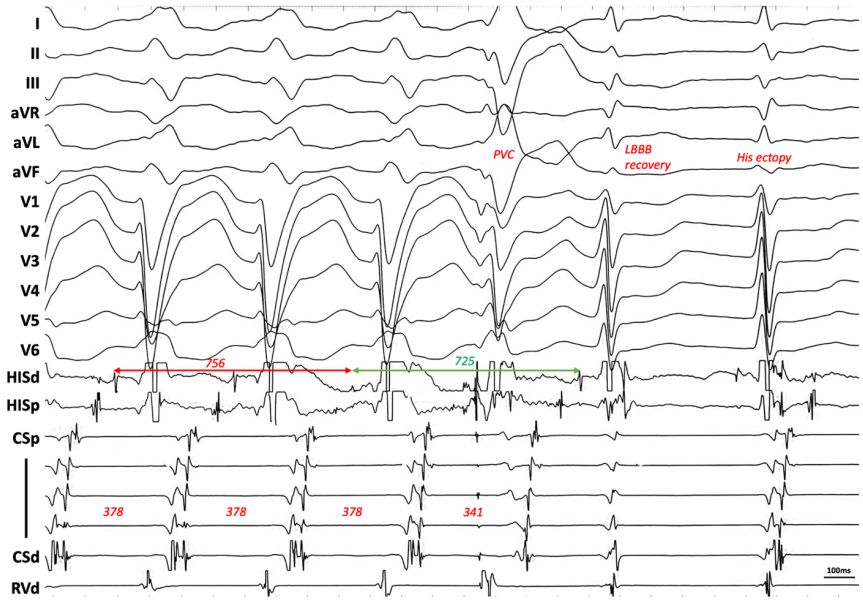

Figure 1 In case 1, a His-refractory PVC was delivered during tachycardia. The next A and subsequent His was advanced, after which tachycardia was terminated with pathway block. The next beat was a catheter-induced ectopy followed by sinus rhythm. See text for discussion. CS=coronary sinus; PVC=premature ventricular contraction; RV=right ventricle.

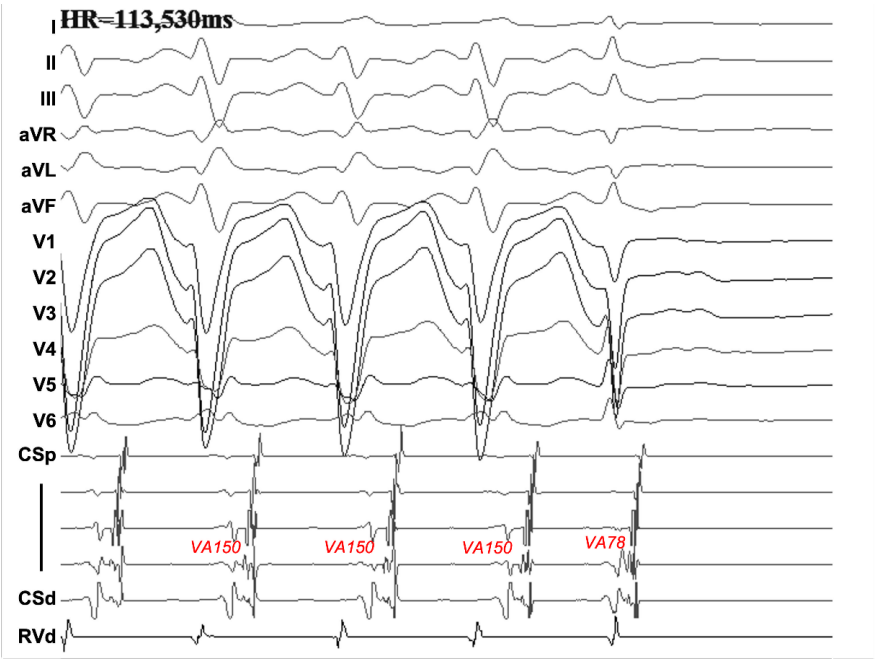

Figure 2 In case 2, ORT with aberrancy was terminated after spontaneous resolution of LBBB, with advanced V and A at mitral annulus. Note the timing of RV apex was almost unchanged. CS=coronary sinus; LBBB=left bundle branch block; ORT=orthodromic reciprocating tachycardia; RV=right ventricle.

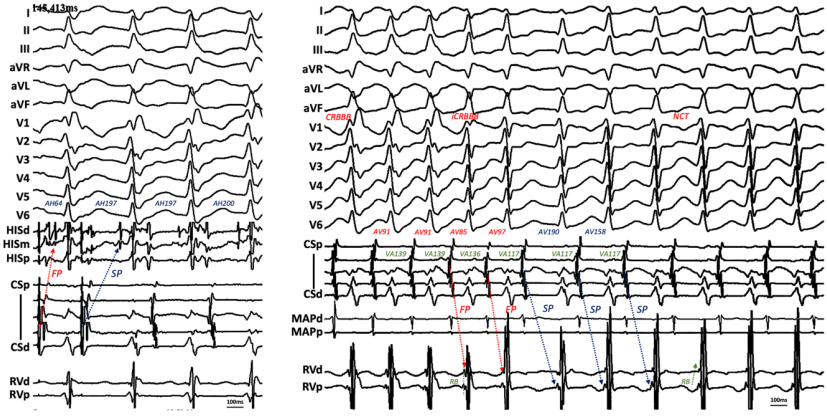

Figure 3 Left panel, in case 3, the 2nd beat conducting over the SP with CRBBB induced ORT, followed by A-H showing SP perpetuation. Right panel, AV conduction was over FP in the first 3 beats, with resolution of CRBBB in the next ones, followed by shortened VA interval and subsequent marked AV prolongation in the 6th beat. Note the subtle change in right bundle conduction. See text for discussion. CRBBB=complete right bundle branch block; CS=coronary sinus; FP=fast pathway; iCRBBB=incomplete right bundle branch block; NCT=narrow complex tachycardia; PVC=premature ventricular contraction; RV=right ventricle; SP=slow pathway.