Rate-Dependent Exit Conduction Block From Pulmonary Vein to Left Atrium After Entrance Block

New Implications of Pacing Rate to Confirm Bidirectional Conduction Block

Atsuhiko Yagishita, MD; J. Rod Gimbel, MD; Mauricio Arruda, MD

Pulmonary vein electric isolation (PVI) is an effective therapy for atrial fibrillation. Bidirectional conduction block between left atrium (LA) and the pulmonary veins (PV) is an accepted end point for PVI. We report a case of rate-dependent unidirectional exit conduction from PV to LA after PVI by large area circumferential ablation, despite entrance and exit conduction block.

A 63-year-old man with symptomatic paroxysmal atrial fibrillation refractory to flecainide underwent PVI. An 8-Fr irrigated ablation catheter (Thermocool RMT) connected to a CARTO3 (Biosense Webster, Diamond Bar, CA) electroanatomic mapping system and Stereotaxis remote navigation system were used for PVI. A circular mapping catheter was used to confirm electrogram-guided PVI by large area circumferential ablation. Isolation of the ipsilateral left PVs was obtained, and bidirectional conduction block between the left PVs and LA was confirmed. Subsequently, isolation of the right superior PV (RSPV) was noted by entrance conduction block. Of note, the left PVs and the RSPV exhibited dissociated spontaneous electric activity suggestive of exit conduction block (Figure 1).

Pacing from the distal bipoles of the ablation catheter at the anterior aspect of the RSPV was performed at a cycle length of 600 ms (10 mV/2 ms). Pacing captured the PV by suppressing its dissociated activity and unexpectedly revealed exit conduction from the RSPV to LA. The same response was obtained by pacing the posterior aspect of the RSPV without changing the atrial activation sequence, which was earlier in the distal coronary sinus than the right atrium. This rate-dependent exit conduction was reproducible, and it was maintained irrespective of lowering the pacing output down to 1 mV, ruling out far-field capture of the superior vena cava. To further assess this rate-dependent unidirectional exit conduction, the cycle length was changed from 600 to 1500 ms and to 1000 ms. Despite PV capture at 1500 and 1000 ms, exit block persisted. However, by pacing at 600 ms, the rate-dependent exit conduction reappeared. Additional ablation along the RSPV large area circumferential ablation lesion set eliminated the rate-dependent exit conduction at baseline and during both adenosine and isoproterenol challenge (Figure 2).

Weerasooriya et al demonstrated that dissociated spontaneous PV activity after PVI represented exit conduction block.1 Duystschaever et al showed spontaneous isolated PV activity in 171 PVs among 135 patients (35% of 378 patients). However, only 1 of the 171 (0.6%) spontaneous potentials exited to the LA.2 In our patient, 2 behaviors of dissociated spontaneous PV activity were present: the left superior PV exhibited the typical exit block, despite its capture by pacing, and the RSPV showed this unique rate-dependent exit PV-LA conduction. This rate-related conduction abnormality may share some mechanisms found to explain bradycardia-dependent conduction block in Purkinje tissue. Even though phase 4 depolarization was initially implicated, El-Sherif and Jalife have demonstrated that phase 4 depolarization distal to an area of impaired conductivity may facilitate propagation, and rate-dependent conduction block can occur without phase 4 depolarization.3 This may be possible by time-dependent variations in the excitability and in the amplitude of slow responses as a result of frequency-dependent changes in the magnitude of slow inward current or time-dependent recovery of early outward current. In our case, rate-dependent exit PV-LA conduction may have occurred because of resting membrane potential repolarization at faster rates, which reverses impulse propagation blockade caused by radiofrequency-induced myocardial depolarization.

Jacobson et al showed rate-dependent entrance (LA-PV) conduction block after PVI.4 However, to the best of our knowledge, this is the first description of rate-dependent exit (PV-LA) conduction. This phenomenon may have clinical implications on recurrences of atrial fibrillation or other atrial tachyarrhythmias after PVI, despite typical maneuvers to confirm bidirectional block and dormant conduction. Theoretically, rapid PV electric activity may promote exit conduction accounting for atrial ectopic complexes, nonsustained or sustained atrial tachycardia, atrial flutters, or even atrial fibrillation. Assessment for rate-dependent exit PV-LA conduction, at various cycle length, may be considered a finding relevant to confirm PV bidirectional conduction block after PVI.

Disclosures

Dr Arruda is consultant for Biosense Webster and Stereotaxis and also received speaker honoraria from these companies. The other authors report no conflicts.

DOI: 10.1161/CIRCEP.115.003871
References

Keywords: atrial fibrillation ■ catheter ablation ■ pulmonary vein isolation

Figure 1. A, Rate-dependent exit conduction from pulmonary vein (PV) to the left atrium (LA). Following pulmonary vein electric isolation (PVI), the right superior PV (RSPV) and left superior PV (LSPV) exhibited entrance conduction block. Note dissociated spontaneous activity at the distal bipolar of the ablation catheter in the RSPV (gray arrow) and at the circular catheter in the LSPV (black arrow). Pacing from within the RSPV at a cycle length of 600 ms (10.0 mA/2 ms) suppressed its spontaneous electric activity and revealed PV to LA exit conduction capturing the LA (asterisk). Note the earliest atrial activation at the distal coronary sinus (CS) bipolar. B, Loss of RSPV to LA exit conduction by pacing at a longer cycle length, 1500 ms and 1000 ms, despite suppression of spontaneous dissociated PV electric activity. RA indicates right atrium.
Figure 2. A, Pacing after additional ablation at gap sites along the right superior PV (RSPV) lesion set. Note that pacing the RSPV at a cycle length of 600 ms no longer facilitated rate-dependent exit conduction from RSPV to LA, despite persistence of dissociated activity within the RSPV (noted pre and post pacing) shown at the distal bipolar of the ablation catheter in the RSPV (gray arrow). Subsequent administration of adenosine and isoproterenol did not promote either spontaneous or rate-dependent PV-LA reconnection. B, Three-dimensional (3D) electroanatomic voltage mapping by CARTO was obtained before PVI. Purple represents voltage >0.5 mV, showing the absence of low voltage areas. Note the ablation catheter (ABL) in the posterior aspect of the RSPV during the pacing maneuvers. C and D, Identification and elimination of gaps by additional ablation using a real-time radiofrequency (RF) energy monitoring system Ablation History by Stereotaxis EPOCH in conjunction with CARTO3. It displays the cumulative energy (W-s) along the ablation lesion set exposing potential gaps. Alternatively, the rate-dependent gaps could have been identified by other specific RF energy tagging systems, voltage mapping or pacing along the lesion set, or even an activation mapping surrounding the lesion set during RSPV pacing. LA indicates left atrium; PV, pulmonary vein; and PVI, pulmonary vein electric isolation.
Rate-Dependent Exit Conduction Block From Pulmonary Vein to Left Atrium After Entrance Block: New Implications of Pacing Rate to Confirm Bidirectional Conduction Block

Atsuhiko Yagishita, J. Rod Gimbel and Mauricio Arruda

Circ Arrhythm Electrophysiol. 2016;9:
doi: 10.1161/CIRCEP.115.003871

Circulation: Arrhythmia and Electrophysiology is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2016 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-3149. Online ISSN: 1941-3084

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circep.ahajournals.org/content/9/6/e003871

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Arrhythmia and Electrophysiology can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation: Arrhythmia and Electrophysiology is online at:
http://circep.ahajournals.org//subscriptions/