Electrocardiographic Imaging of Ventricular Bigeminy in a Human Subject

Yong Wang, MS; Li Li, MS; Phillip S. Cuculich, MD; Yoram Rudy, PhD

Ventricular bigeminy refers to the appearance of paired different ventricular complexes in the body-surface ECG (Figure, A inset, lead V2). From this ECG morphology, it has been inferred that bigeminy is generated by interaction between an extrasystolic beat and a regular periodic ventricular beat.1 The regular beat is typically generated by sinus rhythm but could also be a paced rhythm. The mechanism of ventricular bigeminy was inferred mainly on the basis of analysis of body-surface ECG signals.1,2 However, the ECG measures the reflection in the epicardial surface of the heart. It does not provide detailed information about cardiac activation patterns, data that are necessary for understanding the mechanism of ventricular bigeminy.

Here we apply noninvasive electrocardiographic imaging (ECGI)3 to image ventricular epicardial activation during bigeminy in a patient with atrial fibrillation who underwent atrioventricular node ablation and pacemaker implantation in the right ventricular apex (asterisk in anterior view). ECGI is a functional imaging modality that combines 250 body-surface ECGs with thoracic computed tomography.3,4 By using inverse reconstruction algorithms, ECGI noninvasively generates electroanatomic maps on the epicardial surface of the heart. After extensive validation, it has been applied in human subjects with various cardiac electrophysiological conditions.5–8

The Figure (A) shows the sequence of ventricular activation during bigeminy. The top row demonstrates the regular paced beat, with wavefront propagation from the pacing site to the rest of the heart over a duration of 160 ms because of slow activation in the absence of conduction system participation. The bottom row shows activation during the following beat, with wavefront propagation from a left ventricular ectopic initiation site (triangles in posterior view) to complete ventricular activation in 130 ms. The interaction between the extrasystolic beat and the paced beat generates the bigeminy. Occasionally, we captured and imaged fusion between the paced rhythm and the extrasystole. Such fusion beats are shown in the Figure (B). In the top row, the initiation of paced activation precedes that of extrasystolic activation by 15 ms. This closely coupled biventricular activation increases electrical synchronization and reduces the QRS duration to 100 ms. In the bottom row, the sequence is reversed, and the extrasystole initiation precedes the paced beat by 10 ms, with fusion beats of similar duration but different morphology. These first ECGI images of bigeminy in a human subject provide detailed epicardial activation sequences, confirming the origin of bigeminy in the interaction between an extrasystolic beat and a regular periodic beat.

Sources of Funding
This study was supported by NIH–NHLBI Merit Award R37-HL-33343 and Grant RO1-HL-49054 (to Dr Rudy). Dr Rudy is the Fred Saigh Distinguished Professor at Washington University in St Louis.

Disclosures
Dr Rudy chairs the scientific advisory board of and holds equity in CardioInsight Technologies. CardioInsight Technologies does not support any research conducted by Dr Rudy, including that presented here.

References
 figure. A, The ventricular activation sequence during bigeminy. Top row shows activation sequence for a paced beat from a pacemaker lead located at right ventricular (RV) apex (black asterisk) in the anterior and posterior views (with atria removed). Bottom row shows activation during an extrasystolic beat from a left ventricular (LV) ectopic site (triangles). B, Ventricular activation sequence during 2 different fusion beats between the paced beat and extrasystolic beat. In the top row, the onset of paced activation precedes that of extrasystolic activation by 15 ms. In the bottom row, the extrasystolic onset precedes the paced beat by 10 ms. RA indicates right atrium; SVC, superior vena cava; IVC, inferior vena cava; MV, mitral valve; and TV, tricuspid valve. The solid black line in the posterior view indicates septum location.
Electrocardiographic Imaging of Ventricular Bigeminy in a Human Subject
Yong Wang, Li Li, Phillip S. Cuculich and Yoram Rudy

Circ Arrhythm Electrophysiol. 2008;1:74-75
doi: 10.1161/CIRCEP.107.753194
Circulation: Arrhythmia and Electrophysiology is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2008 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/1/1/74

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/