Title

Unusual response to entrainment of ventricular tachycardia: in or out?

Journal

Heart rhythm, 11(4)

ISSN

1547-5271

Authors

Tung, Roderick
Shivkumar, Kalyanam

Publication Date

2014-04-01

DOI

10.1016/j.hrthm.2013.09.006

Peer reviewed

FEATURED ARRHYTHMIA

Unusual response to entrainment of ventricular tachycardia: In or out?

Roderick Tung, MD, FHRS, Kalyanam Shivkumar, MD, PhD, FHRS

From the UCLA Cardiac Arrhythmia Center, David Geffen School of Medicine at UCLA, Los Angeles, California.

Case presentation

A 70-year-old man with history of inferior myocardial infarction with an ejection fraction of 25% was urgently transferred for ablation of incessant slow ventricular tachycardia (VT).

Electroanatomic mapping revealed extensive inferolateral scar extending to the inferior septum. Entrainment mapping demonstrated an entrance in periannular inferolateral scar with an exit anterior to the aortomitral continuity. Entrainment mapping was performed in the scar at a site in between these 2 regions. Is this response in or out of the circuit? (Figure 1)

Commentary

Entrainment mapping, or continuous resetting of VT, is the gold standard technique for characterizing the components within a reentrant circuit. Demonstration of an isthmus requires the presence of (1) concealed fusion, (2) postpacing interval within 30 ms of the tachycardia cycle length, and (3) stimulus-QRS (S-QRS) interval equal to electrogram-QRS (EGM-QRS) interval.[1] The presence of these responses is highly predictive of termination with ablation.[2,3]

In this case, overdrive pacing of the slow VT (680 ms) is performed at 620 ms (10 mA @ 2 ms). Two distinct diastolic potentials are seen during VT, and it is important to distinguish the near-field EGM captured from far-field components in order to accurately measure the postpacing interval.[4] Disappearance of a local EGM during pacing represents either direct capture or saturation of the channel from pacing. Two features confirm that the early diastolic EGM is not captured during entrainment: (1) the S-QRS interval would be longer as the EGM-QRS occurs in early diastole and (2) analysis of the onset of pacing reveals saturation (Figure 2, dashed circle) from the pacing current in the absence of local and QRS capture.

The last entrained beat demonstrates overt or manifest fusion. The postpacing interval measured to the peak component of the return sensed EGM is within 30 ms of the tachycardia cycle length (680 ms). The S-QRS interval appears to match the EGM-QRS interval when measuring the peak deflection of the late diastolic EGM. These responses suggest entrainment from an outer loop site on the periphery of the reentrant circuit with antidromic fusion outside the circuit.

However, careful analysis of the first 2 paced beats on the tracing demonstrates a QRS morphology with an exact 12-lead match for the VT. The possibility of transient loss of capture during these 2 complexes is ruled out by acceleration of the VT to the pacing cycle length (620 ms). These 2 beats represent concealed fusion with a perfect match for the VT, and the S-QRS interval (145 ms) matches the EGM-QRS interval when the EGM is timed to the onset of the return diastolic potential rather than the peak. Analysis of the diastolic EGM before pacing is useful because the EGM is not yet saturated by the pacing channel, which allows more detailed analysis of multicomponent local EGMs (Figure 2). Closer analysis of this EGM confirms a fractionated component of the late diastolic potential 35 ms before the peak deflection (EGM-QRS interval 145 ms). Note that the first entrained beat after the onset of pacing has the same morphology as the last entrained beat. Interpretation of this entrainment response using the first 2 complexes in Figure 1 suggests a critical isthmus site. Ablation at this site resulted in the abrupt termination of VT within 4 seconds (Figure 3).

We have previously reported the observation of multiple exit site (MES) morphologies when pace mapping within scar during sinus rhythm.[5] These sites are likely specific for reentrant isthmuses and importantly can be identified as surrogates for critical sites in sinus rhythm. However, pacing during sinus rhythm from a point-like source is likely to have a radial spread of activation in contrast to a broad reentrant wave front with a preferential exit during VT. Therefore, activation through MESs out of scar is more likely to be seen during pace mapping. The entrainment response in this case likely represents an alternate exit site from a common

KEYWORDS Ventricular tachycardia; Entrainment
ABBREVIATIONS EGM-QRS = electrogram-QRS; **MES** = multiple exit site; **S-QRS** = stimulus-QRS; **VT** = ventricular tachycardia (Heart Rhythm 2014;11:725–727)

Address reprint requests and correspondence: Dr Roderick Tung, UCLA Cardiac Arrhythmia Center, David Geffen School of Medicine at UCLA, 100 Medical Plaza, Suite 660, Los Angeles, CA 90095. E-mail address: rtung@mednet.ucla.edu.

 http://dx.doi.org/10.1016/j.hrthm.2013.09.006

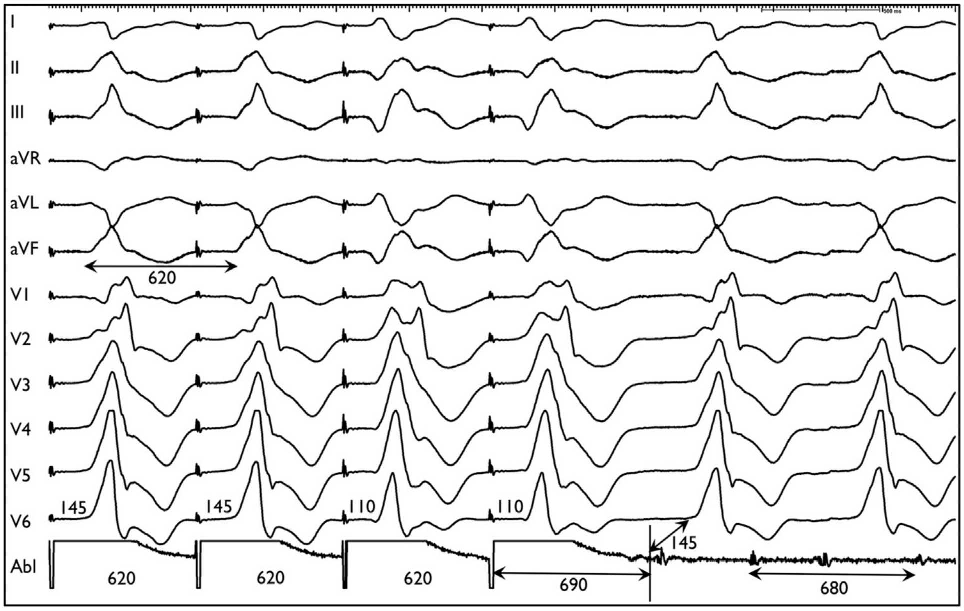

Figure 1 Entrainment response of targeted ventricular tachycardia.

isthmus during VT (Figure 3). To our knowledge, this is the first demonstration of MES during entrainment of VT.

The mechanistic explanation of why a preferential exit switch occurs transiently is not known. The S-QRS interval is longer for the concealed beats than the manifestly fused beats, indicating either slower conduction or greater distance from the respective exit. The shorter S-QRS interval would be expected to exit the scar first, and therefore transient functional block along this exit is the most likely explanation. As overdrive pacing for entrainment is typically performed 10–30 ms faster than the VT cycle length, pacing 60 ms faster in this case may have contributed to this phenomenon. Alternatively, the higher pacing current or catheter movement may have transiently resulted in capture of a larger or more remote area of the myocardium.

The appreciation of MES from a common channel has significant clinical utility where nonmatched pace maps and manifest fusion can be seen at critical isthmus sites.[5,6] The incidence of accessing an alternate exit site during entrainment of VT is unknown, and many sites that are deemed outer loop sites by classical entrainment criteria may indeed represent MES from an isthmus. While the most widely adapted scar construct by Stevenson illustrates a single exit out of an isthmus, complex scar

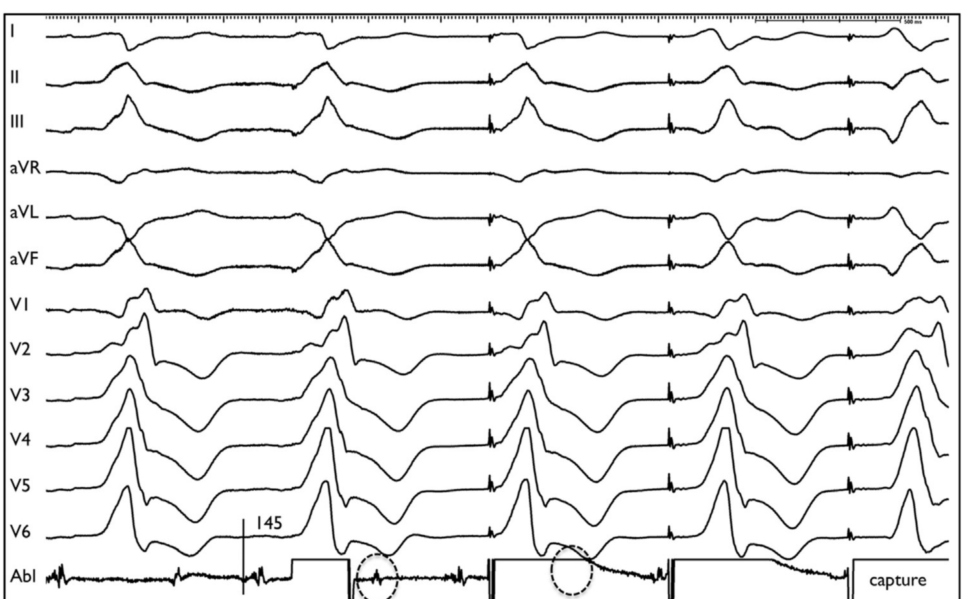

Figure 2 Analysis of local diastolic potentials before the onset of capture during entrainment. The early diastolic component disappears from saturation of the pacing channel before capture. The first captured beat shows the beginning capture of the late diastolic potential from which the electrogram-QRS interval should be measured.

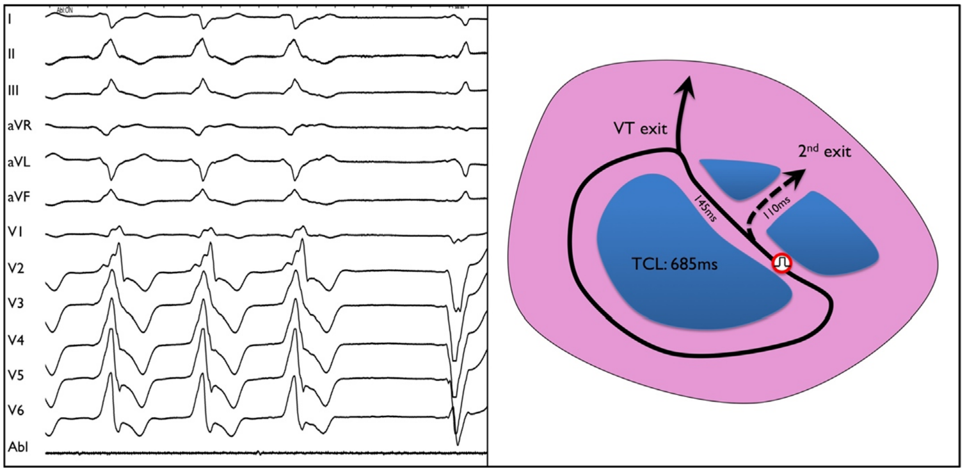

Figure 3 Rapid termination of VT at the entrained site and a schematic of multiple exit sites during entrainment. TCL = tachycardia cycle length; VT = ventricular tachycardia.

architecture likely favors multiple exits out of a common channel. Careful observation of every paced beat can be insightful and decreases the probability of overlooking a favorable ablation target.

References

1. Stevenson WG, Khan H, Sager P, et al. Identification of reentry circuit sites during catheter mapping and radiofrequency ablation of ventricular tachycardia late after myocardial infarction. Circulation 1993;88:1647–1670.
2. El-Shalakany A, Hadjis T, Papageorgiou P, Monahan K, Epstein L, Josephson ME. Entrainment/mapping criteria for the prediction of termination of ventricular tachycardia by single radiofrequency lesion in patients with coronary artery disease. Circulation 1999;99:2283–2289.
3. Stevenson WG, Friedman PL, Sager PT, et al. Exploring postinfarction reentrant ventricular tachycardia with entrainment mapping. J Am Coll Cardiol 1997;29:1180–1189.
4. Tung S, Soejima K, Maisel WH, Suzuki M, Epstein L, Stevenson WG. Recognition of far-field electrograms during entrainment mapping of ventricular tachycardia. J Am Coll Cardiol 2003;42:110–115.
5. Tung R, Mathuria N, Michowitz Y, et al. Functional pace-mapping responses for identification of targets for catheter ablation of scar-mediated ventricular tachycardia. Circ Arrhythm Electrophysiol 2012;5:264–272.
6. Stevenson WG, Sager PT, Natterson PD, Saxon LA, Middlekauff HR, Wiener I. Relation of pace mapping QRS configuration and conduction delay to ventricular tachycardia reentry circuits in human infarct scars. J Am Coll Cardiol 1995;26:481–488.