EP Lab Digest

20 YEARS

A product, news & clinical update for the electrophysiology professional

EP Lab Spotlight

PeaceHealth St. Joseph Medical Center

John MacGregor, MD, FHRS, Associate Medical Director for Cardiac Electrophysiology, Bellingham, Washington

When was the EP program started at your institution? By whom?

Bellingham is a remarkably beautiful coastal city in extreme northwest Washington State. In the early 1980s it had achieved status as a small city worthy of dedicated cardiology support, and North Cascade Cardiology (NCC) was born at that time. As the practice grew concurrently with advances in cardiovascular technology, the need for cardiology subspecialists grew. In the early 2000s, biventricular pacing systems were implanted by one of our cardiologists who had done a year of EP training during an interventional cardiology fellowship.

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In This Issue

Cover Story

Managing a High-Volume Lead Extraction and Management Program

Interview by Jodie Elrod

In this interview, we speak with Robert C. Canby, MD, and Amin Al-Ahmad, MD, about the lead extraction and management program at St. David's Medical Center in Austin, Texas.

Can you give us an overview of the lead management and extraction program at St. David's Medical Center?

Canby: The lead management program at St. David's was created around 2007. As a high-volume EP practice, lead management issues were becoming an increasing part of the responsibilities of electrophysiologists. With all of the devices that we manage, it became clear that meant chronically implanted leads were going to become a bigger issue for all of us. We made the conscious decision at the time to start a lead extraction and management program, and it took off from there.

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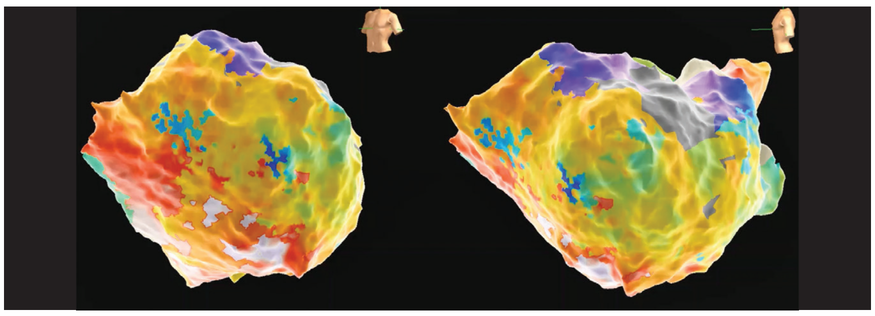
Cover Story

Optimal Ablation Techniques for Ventricular Tachycardia Management: Functional Substrate Mapping With the Sense Protocol

Jason Collinson, BS[1]; Joe Shipton, BS[1]; Neil T. Srinivasan, MBChB, PhD[1,2]



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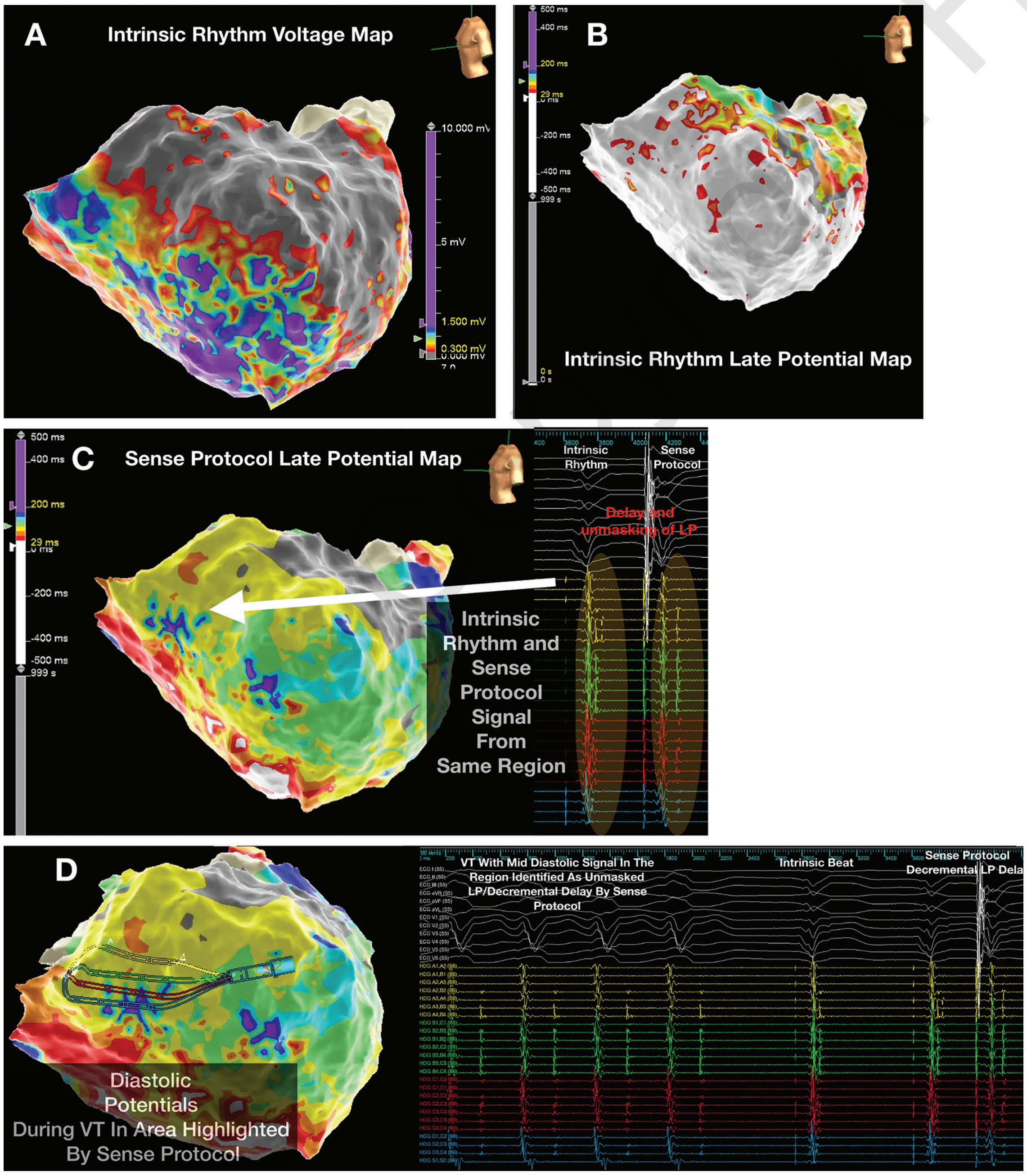
Optimal Ablation Techniques for Ventricular Tachycardia Management: Functional Substrate Mapping With the Sense Protocol

Jason Collinson, BS[1]; Joe Shipton, BS[1]; Neil T. Srinivasan, MBChB, PhD[1,2]

Abstract

Mapping and ablation of infarct-related ventricular tachycardia (VT) remains a challenge. Conventional activation and entrainment methods are limited by poorly tolerated VTs, multiple VTs, complex circuits, and the deleterious effects of inducing VT on cardiac, renal, and cerebral function. The resultant effect is poor long-term outcomes as well as morbidity and mortality. We have developed a dynamic functional method of VT ablation, which in pilot studies, has improved outcomes from VT ablation and may be safer, because it reduces the need for patients to be in VT for prolonged periods of time.

Key words: ablation, functional substrate mapping, substrate mapping, ventricular tachycardia



Outcomes from ablation of ventricular tachycardia (VT) remain poor, with an average of 72% VT freedom for ablation vs 60% for medical therapy[1] in the major randomized trials. This highlights that current ablation strategies do not offer the necessary success rates that may improve mortality. Real-world outcomes from VT ablation may be worse than in the controlled environments of many trials, with outcomes as poor as 44%, major complication rates of up to 12%, a 3.5% rate of cardiac tamponade, and an up to a 2.7% rate of death at 30 days reported in a large UK series.[2] Thus, there is a need for improvement in real-world ablation strategies, both to improve the efficacy and safety of the procedure, as well as to offer patients an improved outcome. Among the limitations of conventional activation and entrainment mapping of VT is the need for VT to be tolerated and sustained long enough to enable detailed mapping to be conducted. Additionally, the process can be time-consuming, requiring serial roving of the catheter to critical regions, pacing maneuvers, and measurement of time intervals.[3] One of the main concerns of this method of mapping VT is the concern with regard to prolonged periods in VT for patients, and the deleterious effects on ventricular function as well as renal and cerebrovascular function from sustained periods of hypotension or abnormal peripheral flow, which may increase the long-term mortality and morbidity in these patients.[4]

To address these challenges, several substrate mapping techniques have been developed;[5,6] however, they are limited to the characterization of the substrate itself and are often time-consuming to perform. Additionally, substrate characteristics are often assessed in a static intrinsic rhythm/sinus rhythm state, which defers from the functional behavior of the tissue that facilitates VT. In light of this, we have developed an automated functional method of VT substrate characterization.

Figure 1. (A) Intrinsic rhythm voltage map showing low voltage in the inferior lateral region and scar border zone anterior/lateral. (B) Intrinsic rhythm paced map showing no significant regions of late potentials (LP). (C) Sense protocol single extra pacing map showing significant functional delay in LP through short coupled pacing (blue and purple regions on map), as demonstrated by the delay in/unmasking of LP signals in the highlighted signal region (yellow region on electrogram tracing). (D) Mapping of ventricular tachycardia (VT) with Advisor HD Grid over the region of unmasked functional LP via the sense protocol, showing mid-diastolic potentials. The VT was not sustained to enable entrainment or activation mapping. The subsequent first two beats in intrinsic rhythm show little or no LP, and the third beat is a short coupled single extra paced beat (sense protocol), showing decremental delay and functional unmasking of the LP in the region of the mid-diastolic signal.

Functional Substrate Mapping: The Sense Protocol

Substrate mapping techniques predominantly involve mapping ventricular scar substrate in intrinsic rhythm; however, VT circuits may be dynamic. VT initiation from device tracings shows that VT is frequently triggered by single extrasystolic beats.[7,8] This suggests that dynamic substrate changes may unmask critical conduction changes that facilitate functional unidirectional block and reentry.

In light of this, we developed a short coupled single extrastimuli protocol (sense protocol [SP])[9] to evoke conduction delay within the tissue and to map hidden abnormal electrograms critical to sustaining VT. In early pilot data, this has been shown to improve procedural outcomes and allow for efficient structured substrate mapping.[10]

To perform the sense protocol, VT substrate maps are acquired with the EnSite Precision Cardiac Mapping System (Abbott) and the Advisor HD Grid Mapping Catheter, Sensor Enabled (Abbott). A catheter is placed in the right ventricular (RV) apex for single extrastimuli pacing. Substrate maps of bipolar voltage and late potentials (LPs) are obtained simultaneously during:

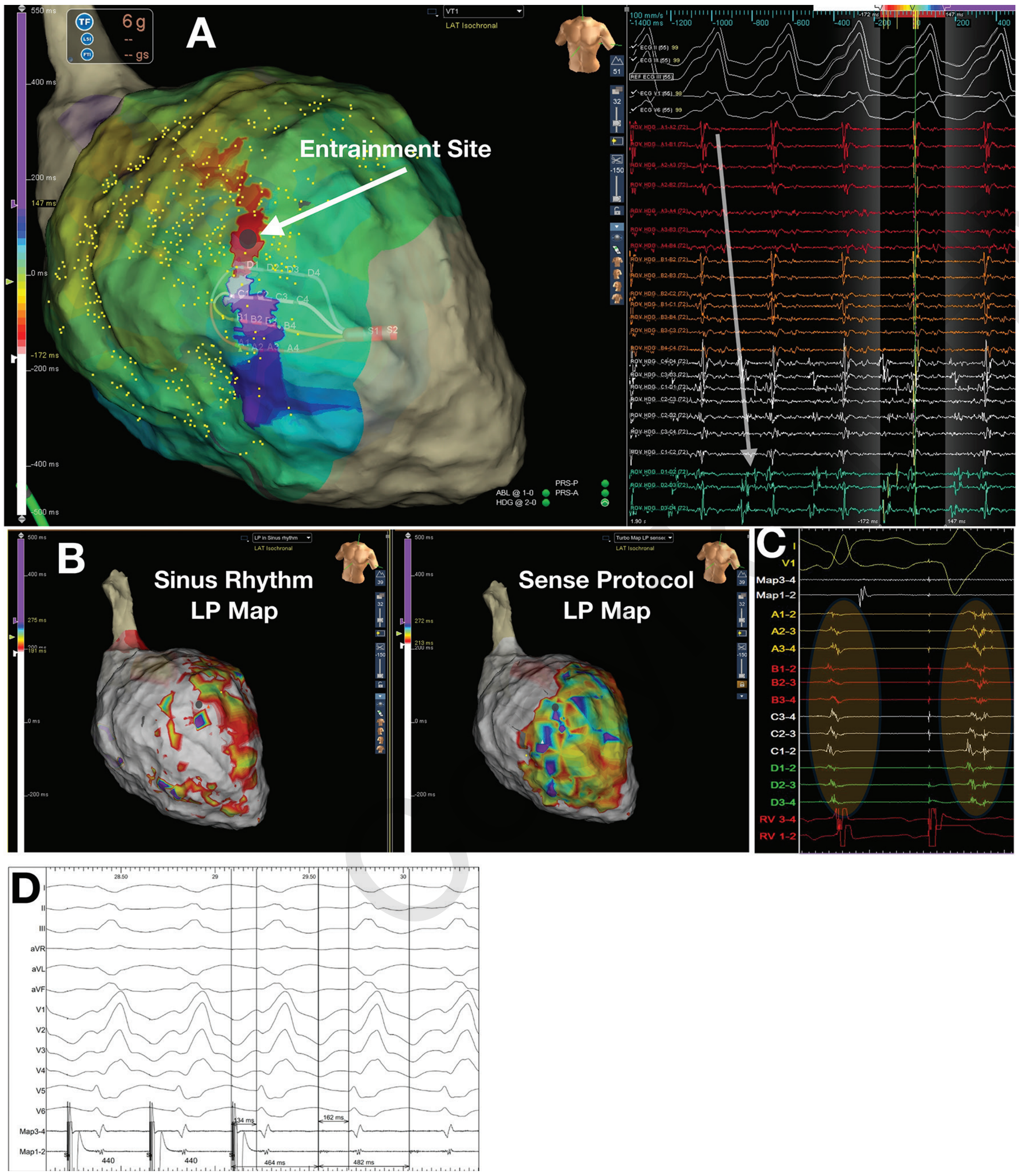


Figure 2. **(A) Activation mapping of VT in a patient with previous anterior myocardial infarction as shown in Video 1. The high-density grid is placed on the critical isthmus, with mid-diastolic signals recorded on the right; it can be seen that the activation sequence goes from spline A to spline D, demarking the entrance and exit of the VT diastolic channel (white arrow). (B) Late potentials (LP) color timing map during sinus rhythm (left) and sense protocol pacing (right) showing a greater region of LP during the sense protocol corresponding to the mapped diastolic pathway of VT. (C) Example of local LP delay and splitting of LP during sense protocol (second beat) along the mapped diastolic pathway of VT. (D) Entrainment from site close to pole D1 on the high-density grid (gray dot) shows concealed entrainment with a post-pacing interval of 18 ms, and a stimulus to QRS duration <30% VT cycle length, indicating entrainment at a VT exit site.** ***Reproduced with permission from Elsevier under a Creative Commons (CC BY-NC-ND 4.0) license.[9]***

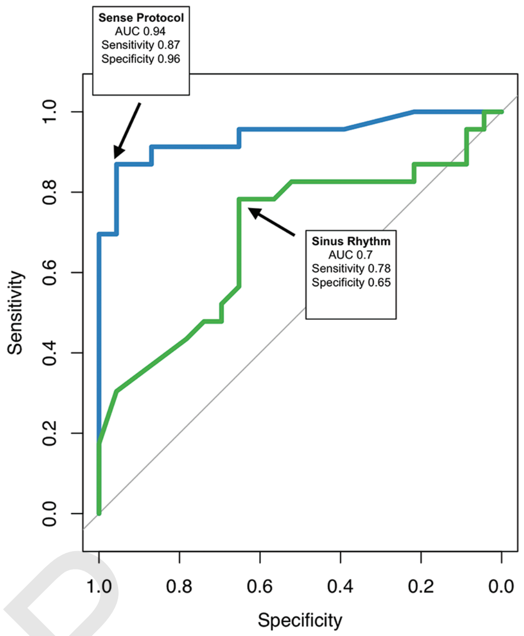


Figure 3. **Improved sensitivity and specificity from sense protocol mapping to critical regions of the VT circuit defined by entrainment or pacemapping, compared to sinus rhythm mapping.** ***Reproduced with permission from Elsevier under a Creative Commons (CC BY-NC-ND 4.0) license.[9]***

- Intrinsic/sinus rhythm, and
- The paced beat of a single (without drive train) sensed extrastimulus from the (RV) apex (SP) at 20-40 ms above the effective refractory period (ERP), which is applied every fifth beat. The TurboMap (Abbott) feature is used to identify the latest LPs from SP pacing.

The average substrate mapping time is 36 mins (± 8 mins) for both maps.

Bipolar LP substrate maps are collected using the HD Wave (Abbott) mapping technology of the Advisor HD Grid, whereby bipolar recording along and across splines is enabled, with the system analyzing orthogonal bipolar wavefronts and recording the highest amplitude of the 2 signals to negate the effect of wavefront directionality. The system is set to annotate the latest LPs identified within the diastolic window. Additionally, the system uses the best duplicate algorithm when analyzing orthogonal bipoles, collecting multiple electrograms beat by beat for a specific point on the map in order to compare signal amplitude for collocated mapping data, and then automatically selecting the electrogram with the highest peak-to-peak voltage in a collected region to display on the map.

Example Cases From the Sense Protocol

Case #1:

A 65-year-old male with ischemic cardiomyopathy, ejection fraction (EF) of 15%, previous coronary artery bypass grafting, and dual-chamber ICD was admitted with multiple ICD shocks and antitachycardia pacing. He had 3 previous failed VT ablations in 2012, 2014, and 2019, and was managed medically

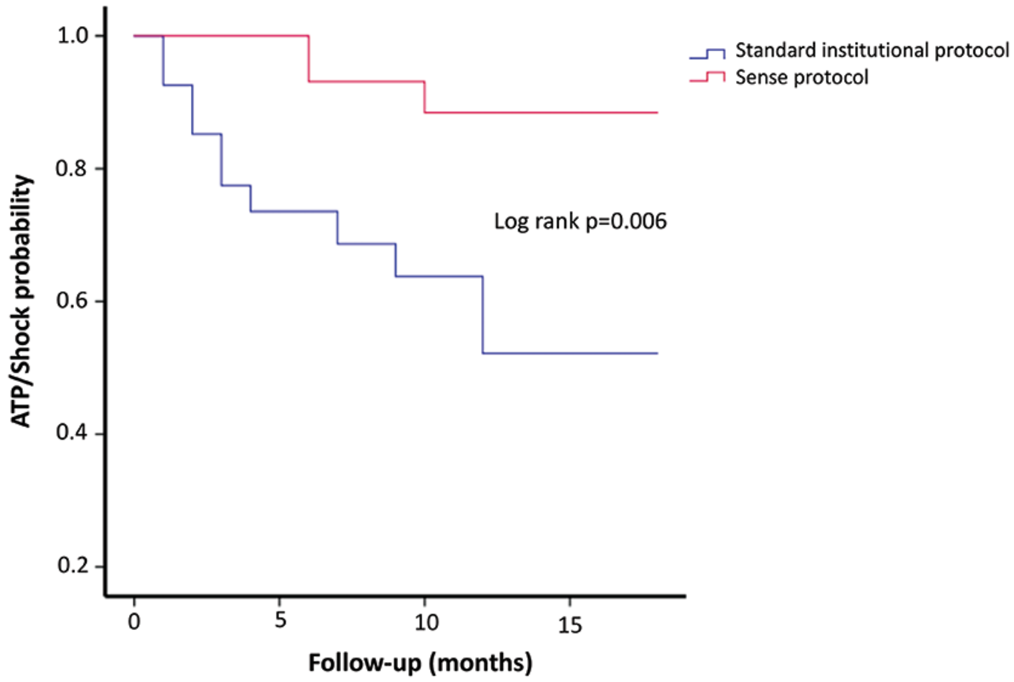


Figure 4. Kaplan-Meier curves demonstrating the probability of ICD therapy with institutional protocol versus sense protocol. Sense protocol ablation resulted in improved freedom from ICD therapy. ***Reproduced with permission from Elsevier under a Creative Commons (CC BY-NC-ND 4.0) license.[9]***

on bisoprolol 10 mg od, amiodarone 200 mg od, and mexiletine 200 mg TDS.

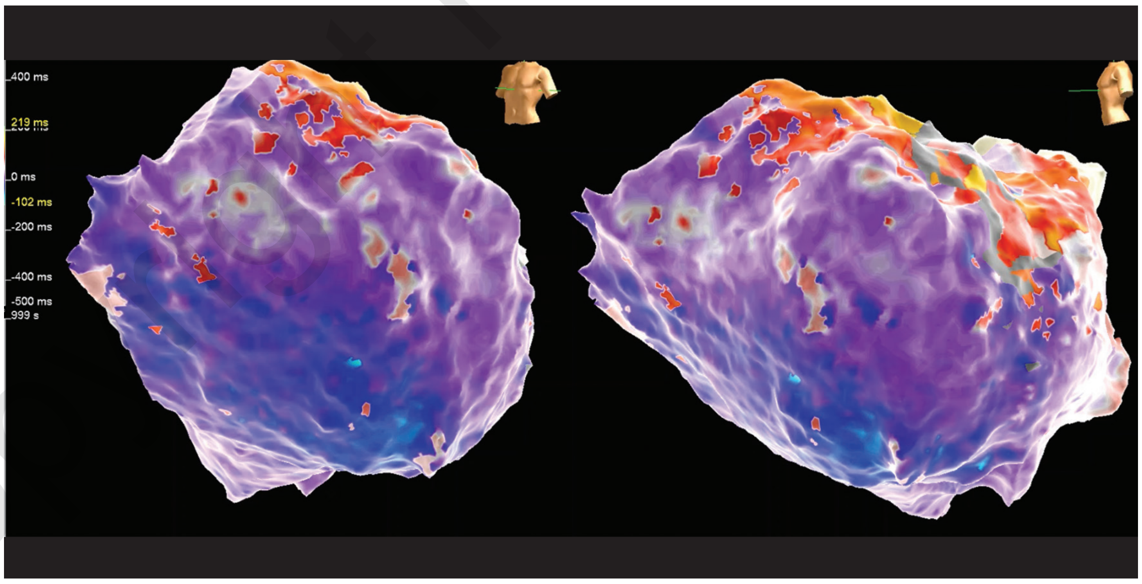
He was taken to the EP lab for further ablation. The previous ablation had utilized an activation/entrainment strategy, and more recently, a substrate ablation of the scar and any late potentials in sinus rhythm, but this had not reduced VT burden. Two substrate maps were performed: one during intrinsic paced rhythm, and the second of the single extra-stimulus beat at short coupling interval.

Figure 1A shows the voltage map of the patient, with an extensive anterior wall scar. Previous ablation had targeted this area and laterally, with no success. Figure 1B shows the sinus rhythm late potential color map, with no significant regions of late potentials. Figure 1C shows the late potential timing map of the single sensed extra (sense protocol), with significant unmasking of LPs in the blue and purple regions. The color scale in Figures 1B and 1C is the same, highlighting the conduction delay and unmasking of LP seen. Figure 1C shows an example of signal within this blue region, where the first beat which is from intrinsic RV pacing shows very little delay and some LP, but the second beat from short coupled single extra pacing showed significant LP decrement and delay.

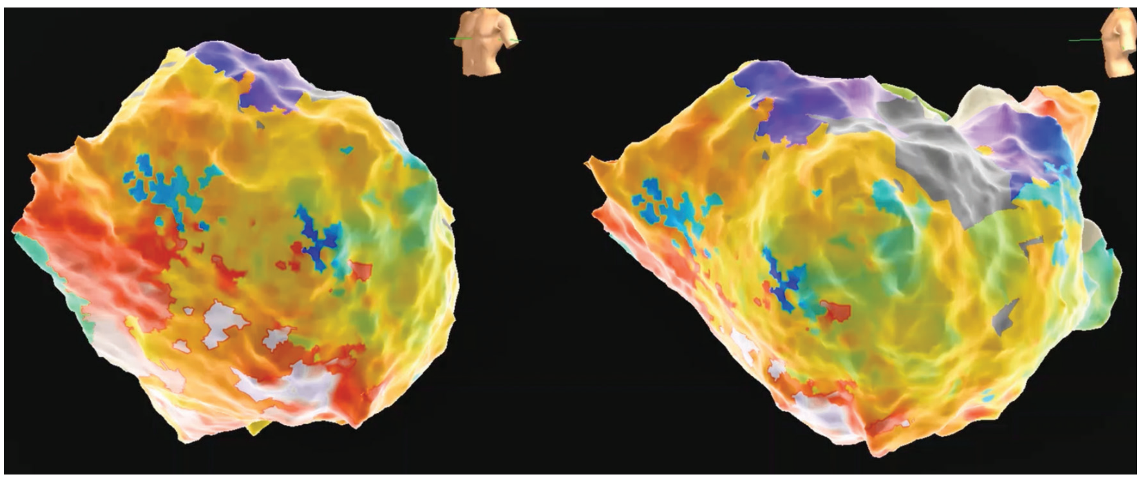
Video 1 shows the wavefront propagation color map of intrinsic rhythm, and Video 2 shows the wavefront delay in the key functional areas through the sense protocol, demonstrated as islands of consistent wavefront discontinuity. Video 3 demonstrates the EnSite LiveView (Abbott) map showing the dynamic delay in LP during live mapping in color.

Figure 1D shows mapping in VT with the Advisor HD Grid over the blue/purple regions of SP-derived unmasked LP; it is positioned over mid-diastolic signals. When VT is terminated and the first 2 intrinsic beats ensue, there is very little LP delay, but the final beat, which is the single extra SP beat, again shows an unmasking and decremental functional delay of LP in this area. The VT was not sustained to enable mapping or entrainment.

Ablation of this region identified by the SP rendered the VT noninducible, and the patient has had no further VT at 12-month follow-up.



Video 1. Intrinsic rhythm wavefront map. ***(Available on www.eplabdigest.com)***

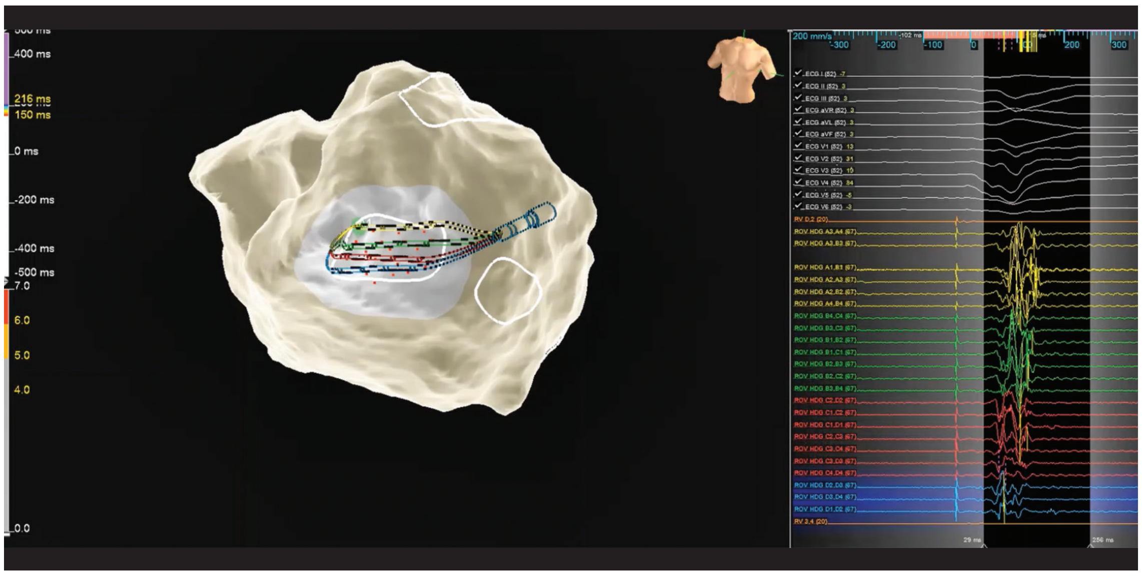


Video 2. Sense protocol wavefront map with regions of unmasked conduction delay. ***(Available on www.eplabdigest.com)***

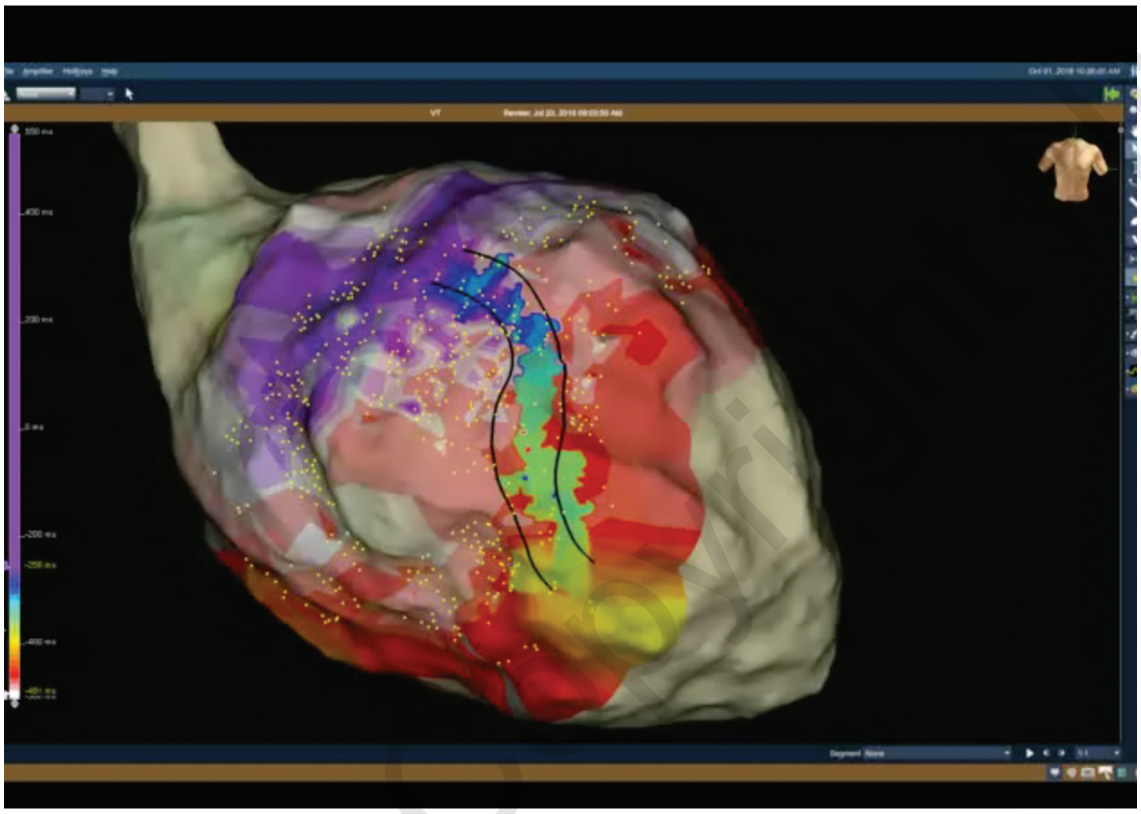
Case #2:

A 52-year-old male was admitted with sustained symptomatic slow VT at 152 beats per minute. He received external cardioversion and was listed for catheter ablation. His EF was 32% and he was on 10 mg bisoprolol od. He was admitted for VT ablation from the device clinic.

A VT ablation was conducted with the Advisor HD Grid as described above. As the VT was sustained, an activation map was performed (Figure 2A and Video 4), with entrainment confirming the circuit (Figure 2D). The sinus rhythm and sense protocol LP maps (Figure 2B) and signals are shown in Figure 2C. It can be seen that the LPs unmasked by the sense protocol are seen within the isthmus



Video 3. **EnSite LiveView (Abbott) mapping using the sense protocol.** *(Available on www.eplabdigest.com)*



Video 4. **Activation map of ventricular tachycardia (from case #2).** *(Available on www.eplabdigest.com)*

of the mapped VT circuit. Ablation of this region rendered the VT noninducible, and the patient has had no further VT at 1-year follow-up.

Conclusion

A significant proportion of VTs are not mappable due to the VT being non-sustained, poorly tolerated, or three-dimensional in nature.[11] The sense protocol allows identification of critical regions, which by nature of their functionality, are critical regions of slow conduction that facilitate VT circuits. Several other functional substrate mapping techniques are published.[12,13] Figure 3 demonstrates the improved sensitivity and specificity of the sense protocol to critical regions of the VT circuit, which may explain the improved outcomes (Figure 4).[9]

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Disclosures: Dr. Srinivasan reports receiving speaker fees from Abbott and Daiichi Sankyo. All other authors have no conflicts of interest to report regarding the content herein.

The videos for this article are available to view at www.eplabdigest.com.

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