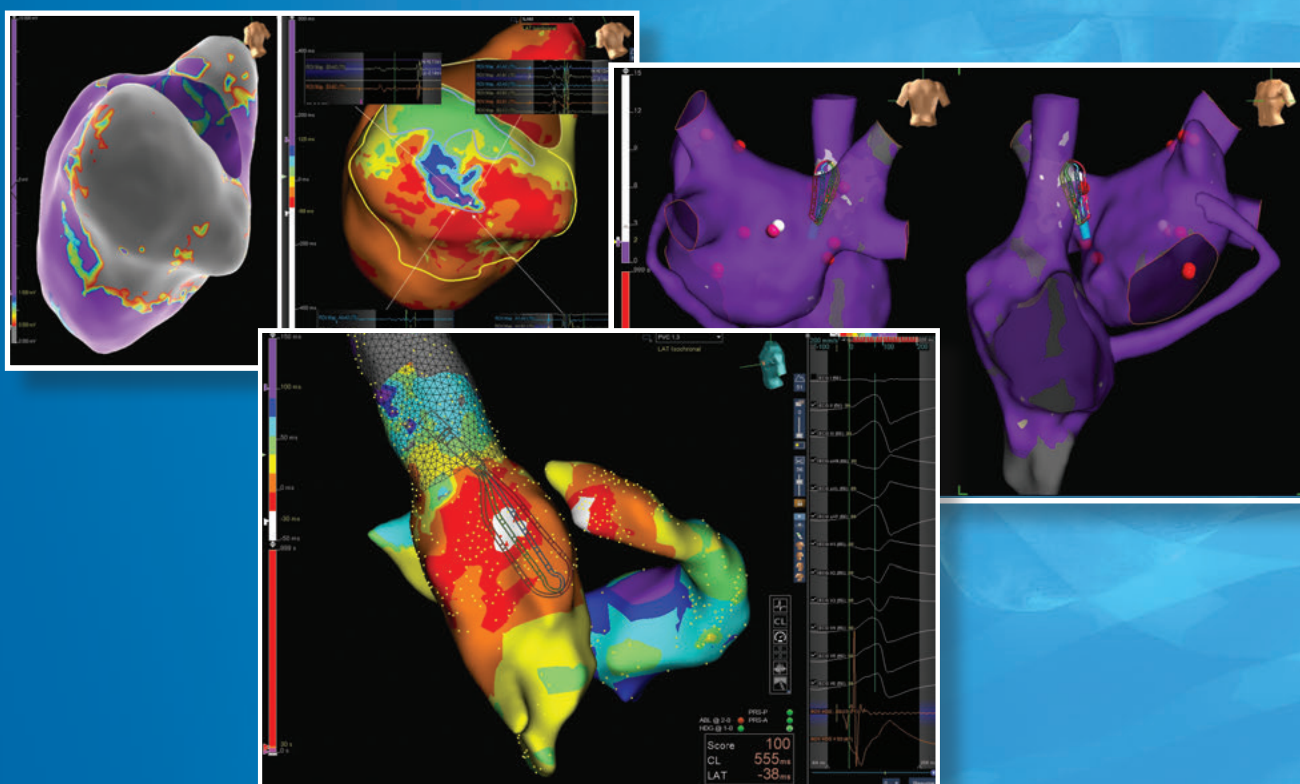
Supplement to January 2021

The Journal of Innovations in Cardiac Rhythm Management™

Case Image Review Compendium:

Featuring: Advisor™ HD Grid Mapping Catheter, Sensor Enabled™



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The Journal of Innovations in
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EXPERT PERSPECTIVES

The Journal of Innovations in Cardiac Rhythm Management™

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FOREWORD

Dear Readers,

The 12-lead electrocardiogram remains the gold standard in three-dimensional mapping of abnormal cardiac electrical signatures and is essential for constructing a preprocedural blueprint. Acquired through the manipulation of electrode-fitted catheters, the electrogram (EGM) is also a fundamental component supporting the diagnosis, mapping, and treatment of cardiac arrhythmias. Visualized and recorded in many ways, yet having its own limitations, the traditionally filtered bipolar EGM is most commonly used. Though bipolar recording limitations such as directionality and contact force influence are universally recognized, they have been significantly lessened with the emergence of the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ (Abbott, Chicago, IL, USA).

The Advisor™ HD Grid catheter is an 18-electrode, four-by-four electrode–compliant splined configuration with an additional bipole located on the shaft for nonfluoroscopic use. This configuration creates a mesh that allows for up to 32 orthogonally oriented recordings to be created. Moreover, the catheter's unique high-density grid design provides solutions for the two most commonly encountered issues in electroanatomic mapping. First is directionality or "bipolar blindness," which is historically well described and studied, such as by Tung et al. in 2016.[1] Initially, with the inception of bipolar EGM technology, paired with the surrendering of unipolar EGM, directionality limitations have become widely scrutinized. Ndrepepa et al. previously helped to demonstrate bipolar and unipolar EGM limitations and value in 1995.[2] High-density grid technology has the ability to facilitate novel techniques such as omnipolar mapping as described by Massé et al.,[3] who concluded that electrode orientation-independent cardiac wavefront trajectory and speed at a single location can be determined with omnipolar EGMs. Other possibilities and future applications could include the collection of four-dimensional information.

The second issue, diagnostic catheter contact assessment, relates to the effects of contact force on electrogram voltage and has been discussed by Mizuno et al.,[4] who showed in 2013 that, with varying degrees of measured force, a proportionate discrepancy in the bipolar EGM recording was apparent. The Advisor™ HD Grid technology has shown the ability to visualize tissue contact based on spline perturbation. Different degrees of perturbance are associated with the results of a rudimentary test measured in grams of force. Grid angulation at 45 degrees equates to 5 g of force, while that at 90 degrees equates to 10 g of force. Visualization of this angulation can also be helpful in preventing complications such as perforation.

Though the ability to localize and reconstruct electrical and physical anatomy safely, accurately, and efficiently is greatly enhanced with the existing knowledge, further studies to show additional uses and future applications are still required. The following supplement includes a compendium of experiences from electrophysiologists who have implemented the Advisor™ HD Grid catheter into their clinical practice.

Sincerely,

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Dr. Patel reports performing consultative work for Abbott and Spectranetics.

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RIGHT ATRIUM

Fractionation Mapping by Using a High-density Catheter to Map Ganglionated Plexus Sites During Sinus Rhythm

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KEYWORDS. *Cardiomyopathy, epicardial, high-density mapping, ventricular tachycardia.*

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Ablation of the ganglionated plexi (GPs) is a relatively new technique aiming to prevent the autonomic imbalance in vasovagal syncope (VVS) from occurring. To confirm localization of the GPs, the potential usage of fragmented electrograms with visual analysis was firstly defined by our group.[1] However, decisions made by humans based on the visual review of data may demonstrate low reproducibility.

As a new software, the fractionation mapping tool of the EnSite Precision™ cardiac mapping system was successfully used to detect GP sites during atrial fibrillation.[2] A 18-year-old male with cardioinhibitory-type VVS was admitted with recurrent syncopal episodes despite physical counterpressure maneuvers and medications. The right and left atria were mapped with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™. Bipolar recordings were filtered at 200 to 500 Hz. A fractionation map was created using combinations of width (5 ms), refractory time (30 ms), roving sensitivity (0.1 mV), and fractionation threshold.[2] Technical details were discussed in our previous work.[3] White areas on the map were accepted as potential GP sites and defined as targets of ablation **(Figure 1)**. After all GP targets were identified, radiofrequency ablation of the targeted areas was initiated according to our ablation order of GPs (ie, the left superior GP, the Marshall tract GP, the left inferior GP, the right superior GP via the left atrium, and the right inferior GP via the left atrium, respectively.[4] Radiofrequency energy application at left-sided GPs triggered a vagal response with sinus bradycardia. Meanwhile, during radiofrequency ablation at the right superior GP, the patient's heart rate increased from 976 to 620 ms **(Video 1)**. The procedure was ended with ablation of the right superior GP via the right atrium. The final P–R interval was detected as 110 ms, which was comparable with preoperative atropine challenge results. The use of fractionation mapping software with application of the Advisor™ HD Grid mapping catheter may be used to localize GPs.

The authors report no conflicts of interest for the published content.
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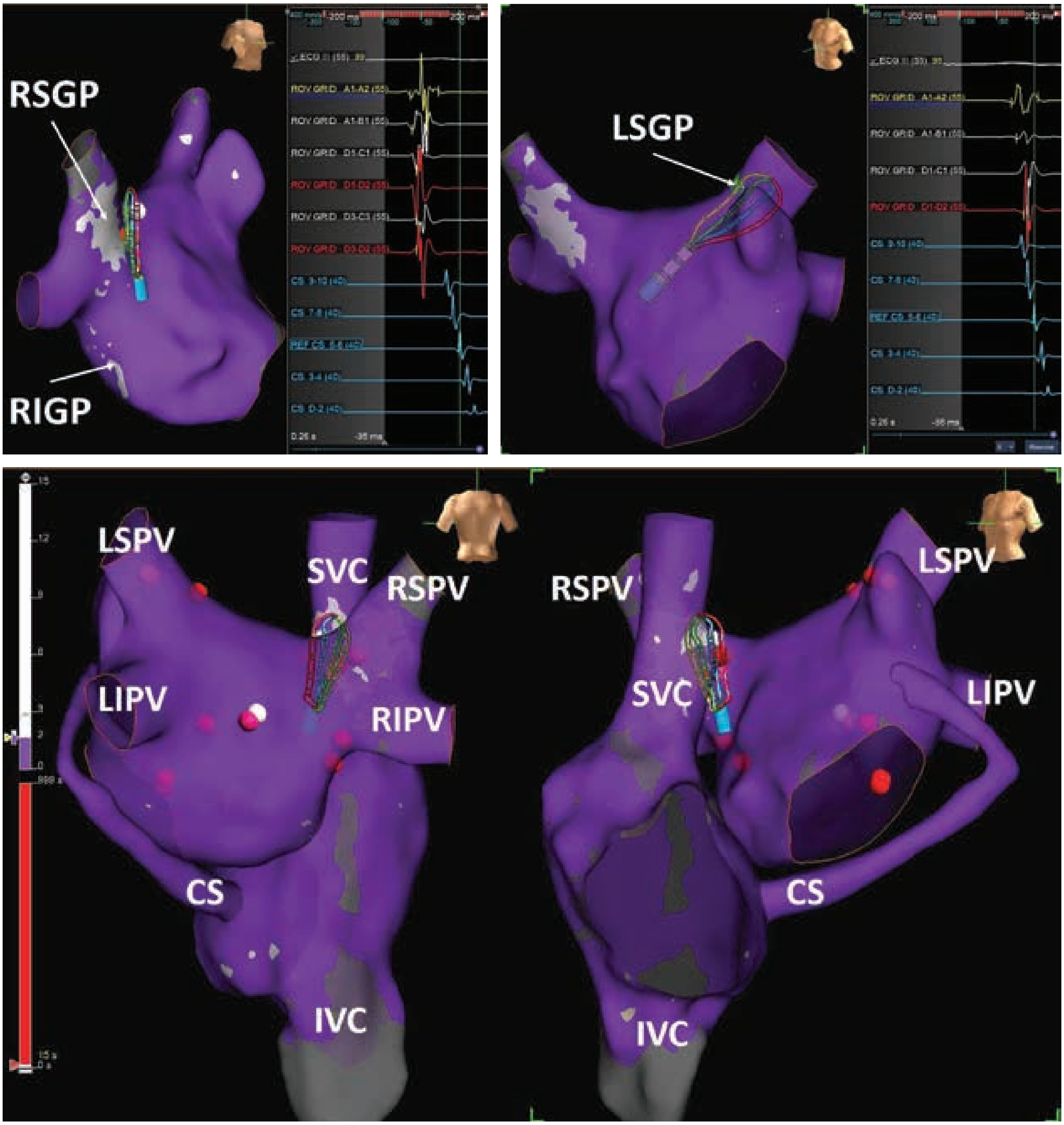

Figure 1: Localization of ganglionated plexuses based on fractionation mapping algorithm by using the Advisor™ HD Grid catheter.

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RIGHT ATRIUM

High-density Mapping Facilitates Successful Ablation of Postincisional Right Atrial Flutter After Previous Mechanical Mitral Valve Replacement

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KEYWORDS. *Atypical atrial flutter, high-density mapping, postincisional atrial reentrant tachycardia.*

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A 44-year-old woman presented with permanent atypical atrial flutter (AFL) with a constantly elevated heart rate of 115 bpm due to 2:1 ventricular conduction. The patient had a long-standing history of chronic polycystic kidney disease with three complicated transplantations resulting in chronic hemodialysis and multiple shunt revisions. After severe sepsis with endocarditis, she underwent mechanical mitral valve replacement (29 mm) seven years ago. Rhythm control was ineffective despite four attempted direct-current cardioversions and she was referred for catheter ablation to prevent tachymyopathy. Computed tomography imaging of both atrial chambers was used to enhance electroanatomical mapping with the EnSite™ system. Entrainment pacing excluded cavotricuspid isthmus–dependent right and perimitral left atrial flutter. Right atrial mapping with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ (18,700 map points; 2,800 points used) revealed a reentrant circuit covering the complete cycle length of 270 ms **(Video 1)**. The activation map demonstrated a wavefront around the anterolateral superior vena cava involving the postincisional roofline toward the interatrial septum from previous valve surgery. Highly fractionated (150 ms), low-amplitude (0.1–0.3 mV) signals were recorded along the presumed atriotomy, delineating the early-meets-late region **(Figure 1)**.

Due to documented episodes of sinus and junctional bradycardia, ablation was performed after pace termination during sinus rhythm and phrenic nerve pacing for safety reasons. An irrigated contact-force ablation catheter was used (30 W) to target abnormal signals severing the upper reentry circuit. The linear lesion was extended in a superior to inferior direction, connecting adjacent scar borders (< 0.1 mV) according to the voltage map. Noncapture along the ablation line as well as noninducibility of AFL were considered as valid endpoints of the procedure. With the restoration of stable normal sinus rhythm (53–106 bpm), the patient improved clinically and showed no recurrences of atrial tachyarrhythmias during follow-up.

Mr. Lassnig is a supporting technician of Abbott. The other authors report no conflicts of interest for the published content.
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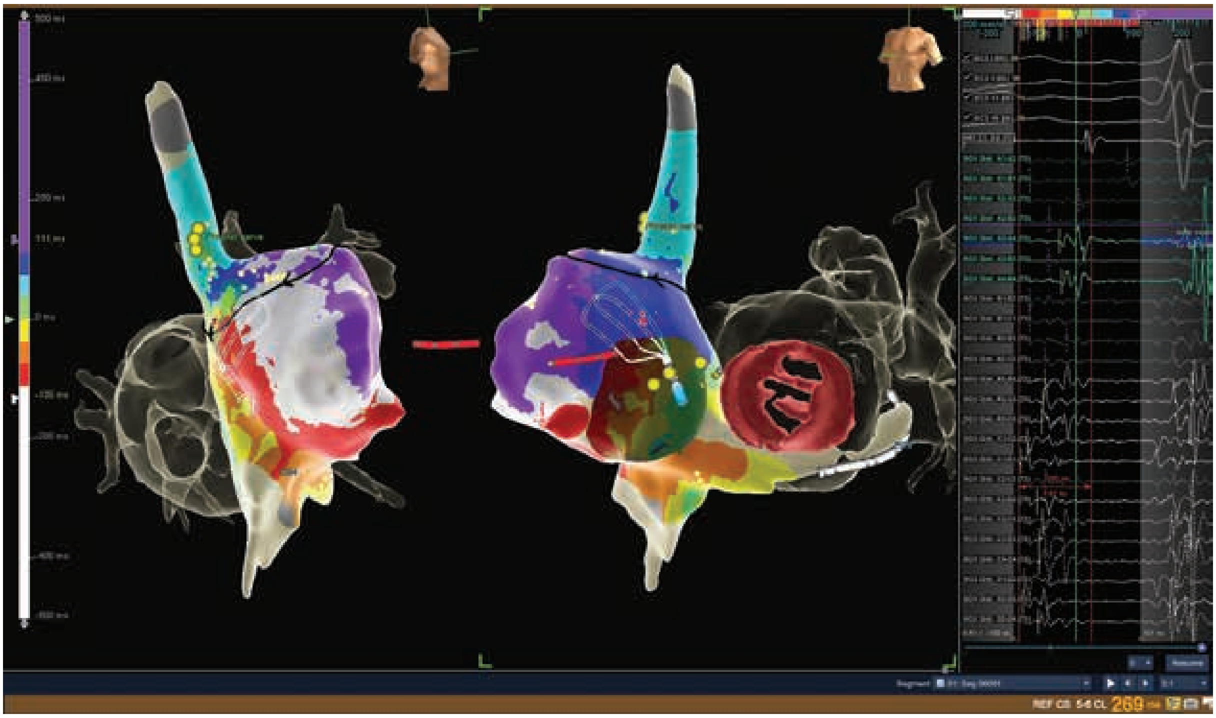

Figure 1: Activation mapping of the right atrial chamber was performed with the sensor-enabled Advisor™ HD grid catheter (right and left anterior oblique projections). The postincisional right atrial flutter (cycle length: 270 ms) demonstrated an upper reentrant circuit (depicted by the black arrow) involving previous atriotomy lines for mitral valve replacement. Highly fragmented, low-amplitude signals were detected (right panel) using the Advisor™ HD Grid catheter and served as a successful ablation target in the early-meets-late zone along the anterolateral superior vena cava/right atrial appendage region.

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RIGHT ATRIUM

High-density Mapping of a Posteroseptal Accessory Pathway Using Open-window Mapping

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KEYWORDS. *Ablation, accessory pathway, Advisor HD Grid, high-density mapping, open-window mapping.*

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A 21-year-old man with a family history of Wolff–Parkinson–White syndrome and a personal history of chest pain and palpitations was referred for ablation. The baseline electrocardiogram (ECG) showed sinus rhythm at 62 bpm with a P–R interval of 80 ms, a QRS duration of 130 ms, and a corrected QT interval of 422 ms. There was a delta wave that was positive in leads I, II, and aVL; isoelectric in leads III and aVF; and negative in V1 but positive in V2 **(Figure 1)**.

High-density, three-dimensional mapping was performed across the posteroseptal aspect of the tricuspid valve during sinus rhythm using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ and the EnSite Precision™ electroanatomic mapping system. We employed the open-window mapping (OWM) strategy described by Schricker et al.[1] OWM relies on the maximum absolute dV/dt value from each bipolar signal on the high-density grid to collect activation points in patients with accessory pathway conduction. The "open window" does not distinguish atrial, pathway, and ventricular signals from one another and mapping leads to visualization of the channel of activation across the mapping segment (in this case, the tricuspid valve). We localized the precise pathway location within the right inferoparaseptal (posteroseptal) region **(Video 1)**.

Ablation was performed with the TactiCath™ DF, Sensor Enabled™ catheter set at a flow of 17 cc/minute, power of 25 W, and a goal contact force of 8 to 40 g, delivered for 10 to 30 seconds per lesion. Aided by high-density mapping, the pathway was eliminated successfully. In follow-up, the patient has remained symptom-free with no evidence of preexcitation on subsequent ECGs.

Acknowledgments

The author would like to thank Madeline Ferraro, Ryan Coleman, and Andrew Campadonico of Abbott Medical for their mapping assistance and for assistance in obtaining images and movies.

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The author reports receiving honoraria for speaking engagements from St. Jude Medical/Abbott.
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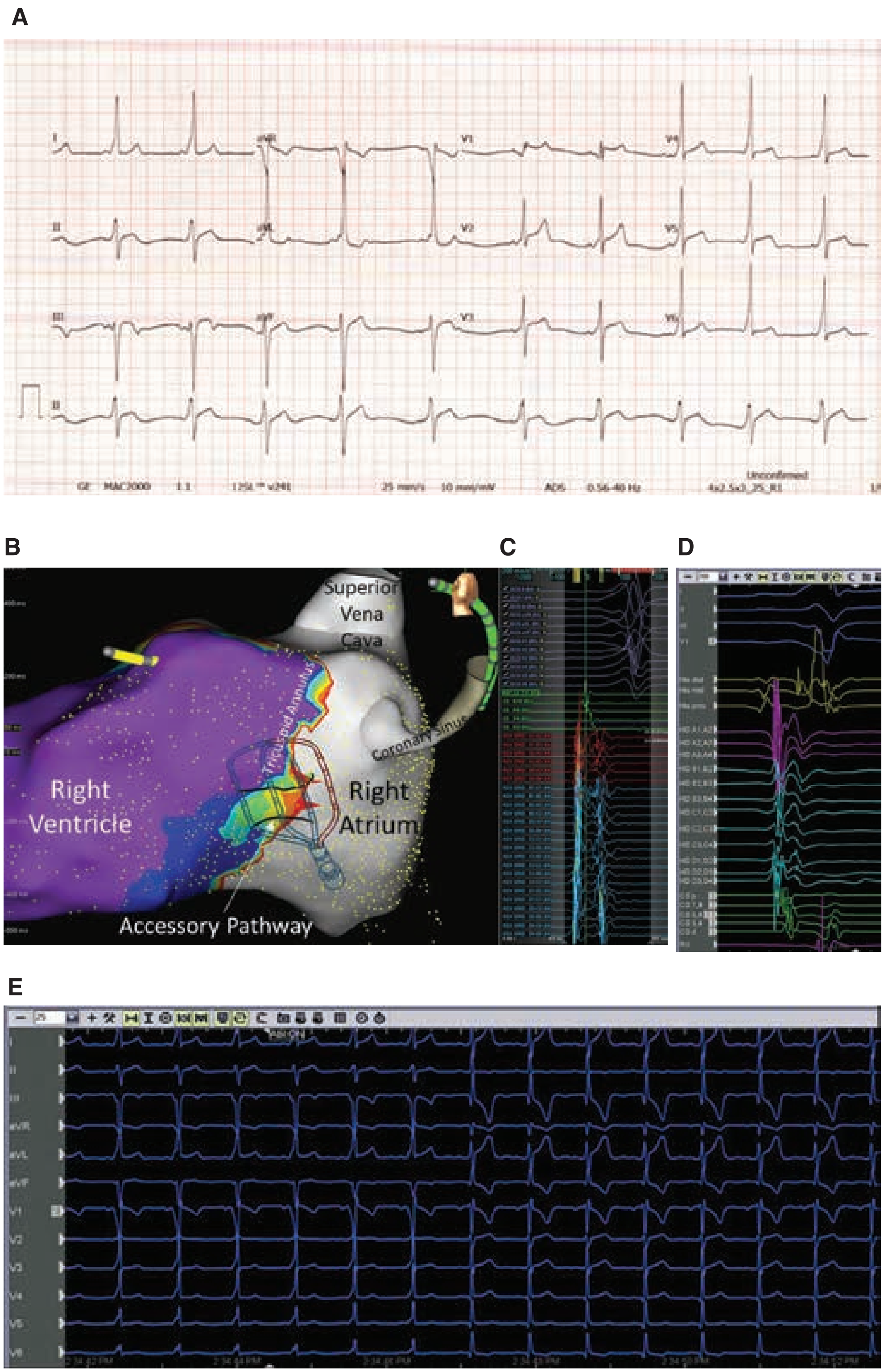

Figure 1: The value of high-density mapping using an OWM strategy. **A:** Preablation ECG showing preexcitation. **B:** High-density map of the right atrium, tricuspid annulus, and right ventricle using the Advisor™ HD Grid catheter to localize the posteroseptal location of the accessory pathway. **C:** High-density grid signals at the accessory pathway (AP) site recorded with the EnSite Precision™ electroanatomic mapping system. **D:** High-density grid signals at the AP site recorded from the GE CardioLab™ (GE Healthcare, Chicago, IL, USA) recording system. **E:** ECG during ablation showing elimination of the AP.

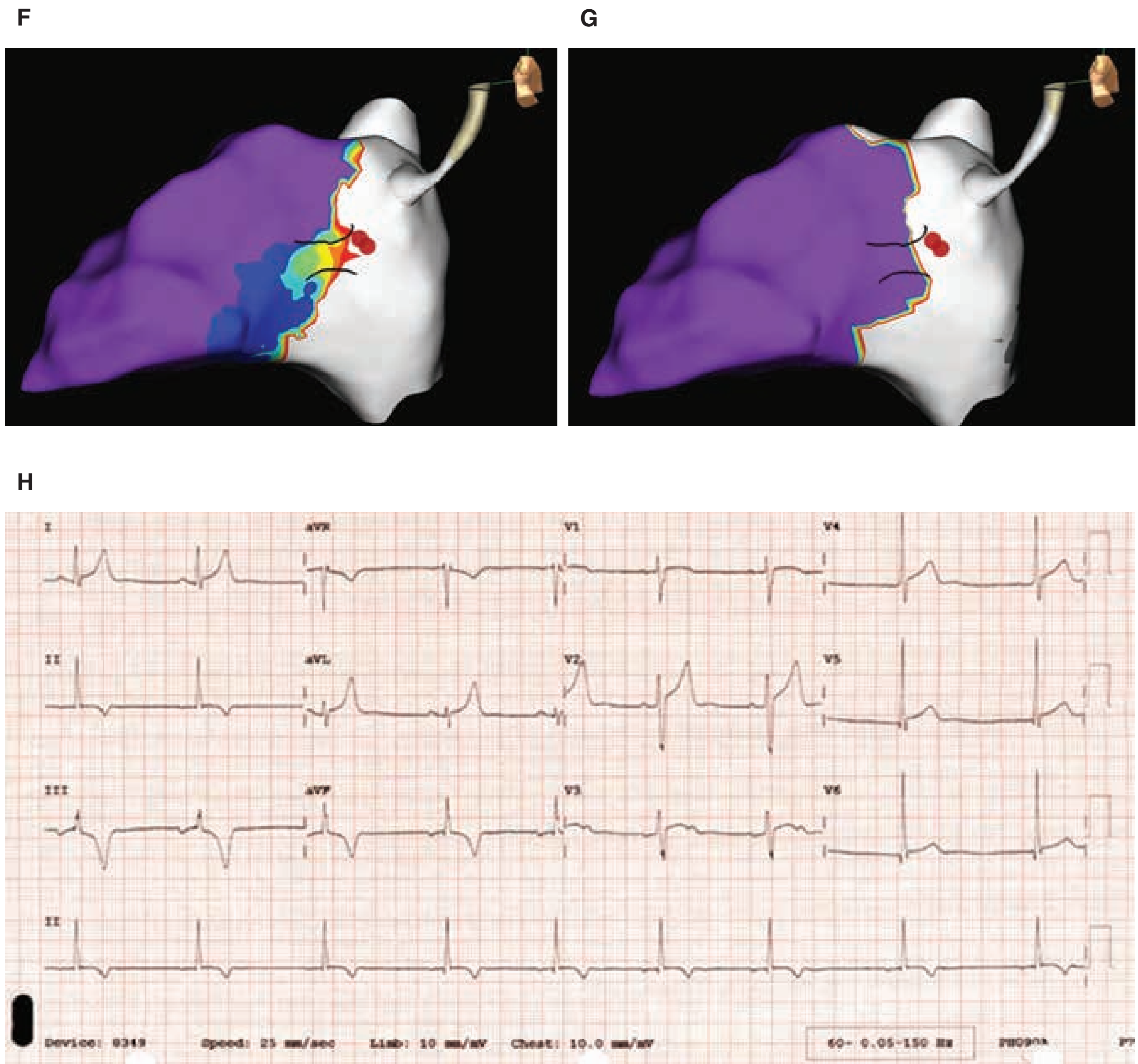

Figure 1: F: Activation map showing the location of the AP and successful lesion sites prior to ablation, while there is still AP conduction. **G:** Activation map showing the location of the AP and successful lesion sites after ablation when there is no longer AP conduction. **H:** Postablation ECG showing no preexcitation.

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RIGHT ATRIUM

High-quality and Fast Mapping of a Focal Atrial Tachycardia Arising from Koch's Triangle

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KEYWORDS. *Dynamic mapping, focal atrial tachycardia, high-density mapping.*

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Focal atrial tachycardias arise with different mechanisms, including from atrial structures where ablation is dangerous to perform and detailed mapping is necessary but time-consuming. Recently, a new software, EnSite™ LiveView Dynamic Display, was introduced to provide a fast, real-time beat-to-beat analysis of electrical information.

A 43-year-old woman without previous illness presented in our department with a long history of palpitations and supraventricular tachycardia interrupted with adenosine. We performed an electrophysiological study in our electrophysiology laboratory, confirming with pacing maneuvers the diagnosis of atrial tachycardia conducted with right bundle branch block aberrancy and initiated mapping using the Ensite Precision™ mapping system and the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™. At the beginning, we adopted the traditional static local activation map (15 minutes) to identify a macro-region of interest in the septum near the triangle of Koch **(Video 1, part 1)**. Afterward, the EnSite™ Liveview software was used to more quickly (80 seconds) and precisely localize the site of earlier local atrial activation at the coronary sinus ostium **(Figure 1 and Video 1, part 2)**. Using a Blazer™ 4-mm ablation catheter (Boston Scientific, Natick, MA, USA) in this single site, we interrupted the atrial tachycardia after four seconds of radiofrequency energy (temperature control 50 W, 60°) **(Video 1, part 3)** with a few irritative junctional beats; two additional lesions were delivered to consolidate lesion formation at the site of successful termination (average: 39 W, 56°C).

Two conclusions can be drawn from this case. First, detailed mapping using the Advisor™ HD Grid catheter yielded a precise map that permitted us to create less lesions, avoiding further dangerous and unnecessary ones. Second, this case demonstrated utility of the new EnSite™ Liveview software in terms of its capacity for rapid mapping.

The authors report no conflicts of interest for the published content.
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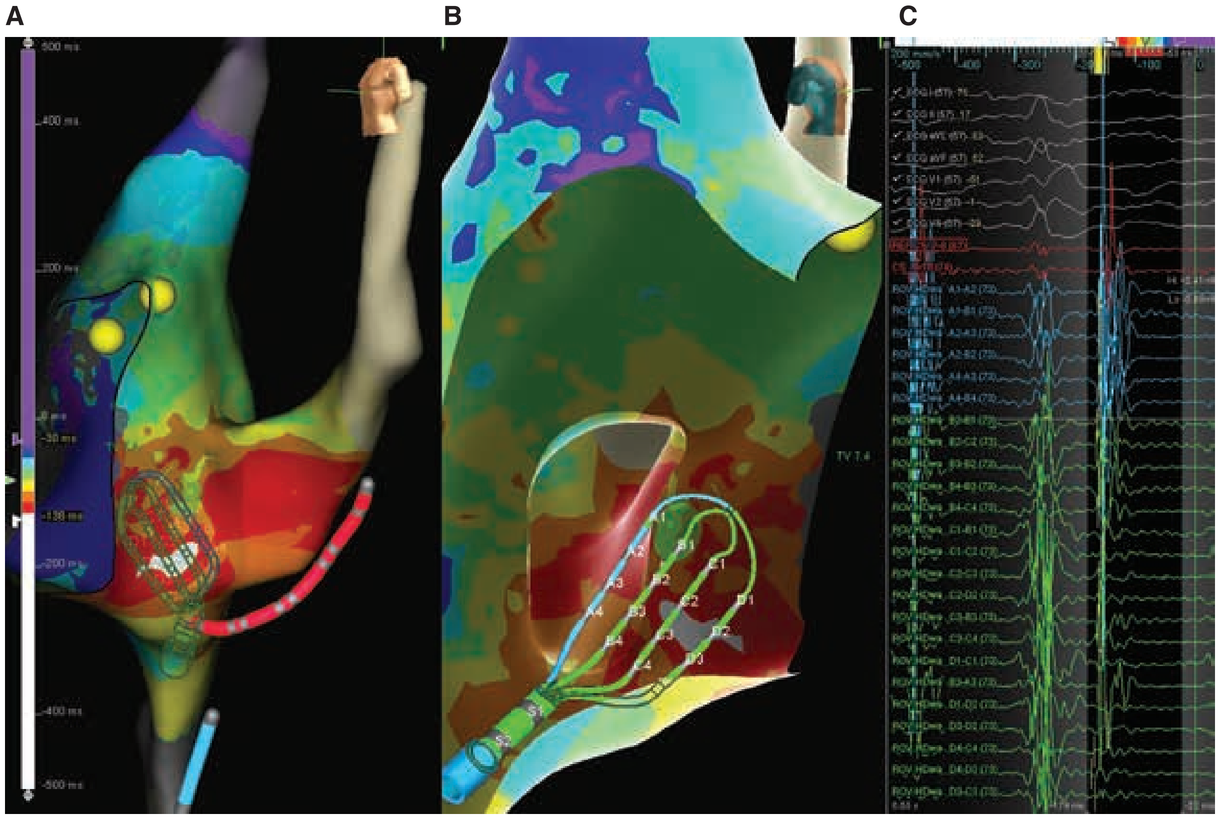

Figure 1: Traditional electroanatomical activation map (**A:** left anterior oblique view; **B:** right anterior oblique view). **C:** Signals recorded with the Advisor™ HD Grid during the focal atrial tachycardia in the Koch's triangle region.

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RIGHT ATRIUM

Termination and Block of Typical Atrial Flutter as Shown by Advisor™ HD Grid Technology

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KEYWORDS. *Atrial flutter, arrhythmia, supraventricular tachycardia, ablation.*

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A 65-year-old male patient with no comorbidities presented with palpitations. A diagnosis of typical atrial flutter was established based on a sawtooth pattern on the electrocardiogram with negative flutter waves in the inferior leads and positive flutter waves in V1. The atrial flutter was found to be refractory to medical therapy with β-blockers; thus, the decision to proceed with ablation was made.

In **Figure 1**, the high-density grid catheter (Advisor™ HD Grid Mapping Catheter, Sensor Enabled™) is displayed in a caudal view of the right atrium. Intracardiac electrograms are shown on the bottom. Following the activation sequence of white → red → orange → yellow → green → light blue → dark blue → purple, the counterclockwise mechanism is presented in **Figure 1A**. With an additional ablation lesion at the ablation catheter tip, the tachycardia was terminated and the activation pattern changed from counterclockwise to approaching the cavotricuspid isthmus from a clockwise direction, indicating that block had been achieved; this can be observed with the change in activation pattern in **Figure 1B**. Note that, the earliest color, white, is now seen on the septal side of the cavotricuspid isthmus **(Video 1)**.

The patient remained well and in normal sinus rhythm six weeks after ablation.

Dr. Sundaram and Dr. Choe are consultants for Abbott and have received honoraria for lectures and training. The other author reports no conflicts of interest for the published content.
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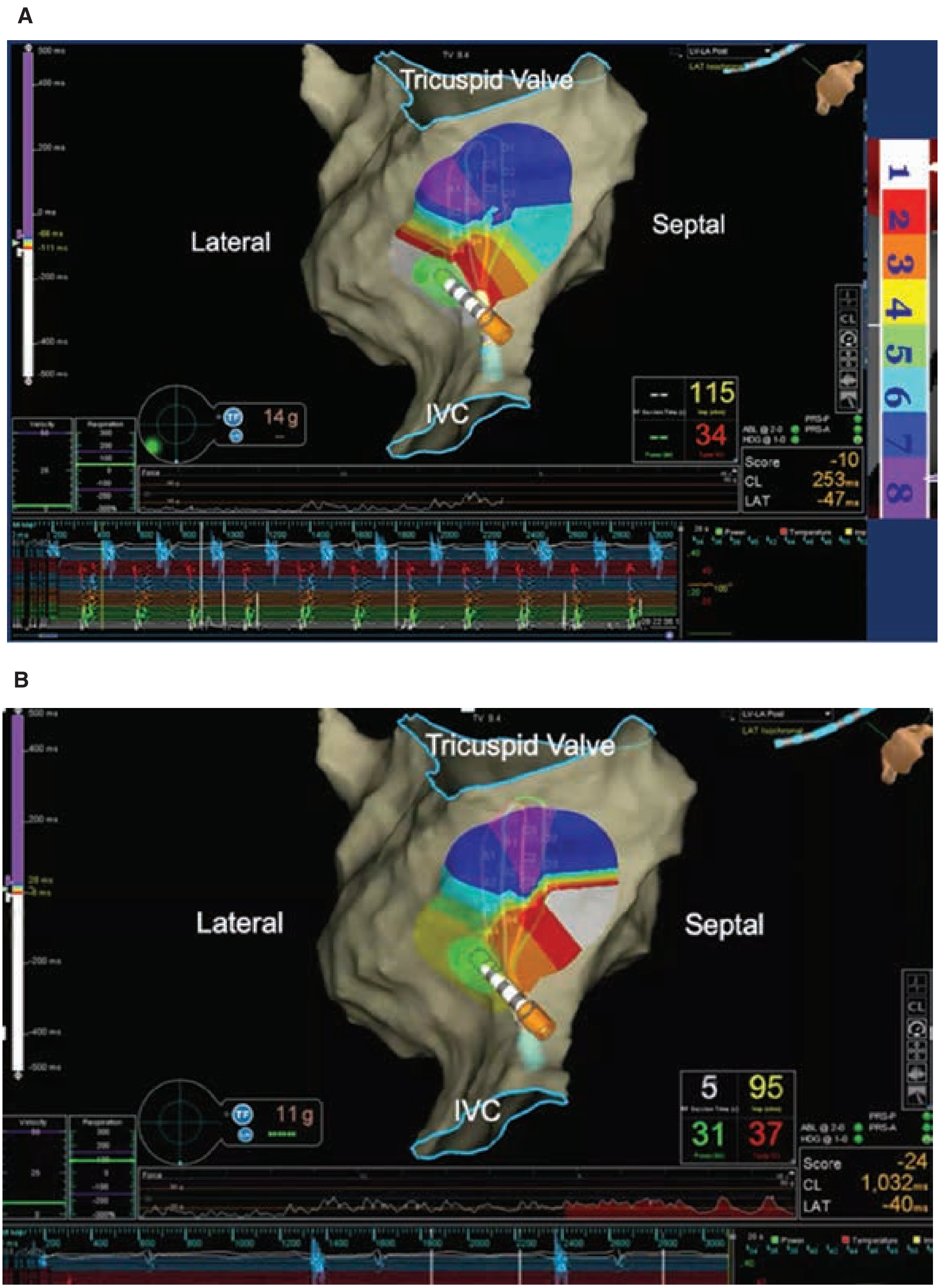

Figure 1: A: The Advisor™ HD Grid and ablation catheters are displayed in a caudal view of the right atrium. Intracardiac electrograms are shown on the bottom. Following the activation sequence of white → red → orange → yellow → green → light blue → dark blue → purple, the rhythm was confirmed as typical counterclockwise flutter. **B:** The tachycardia terminated and normal sinus rhythm resumed. Note that the color scheme reversed into a clockwise pattern with this achievement, which indicates that block has been achieved as the activation pattern has changed.

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LEFT ATRIUM

Localizing Left Atrial Flutter Using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™

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KEYWORDS. *Atrial flutter, Advisor HD Grid catheter, high-density mapping, local activation time.*

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High-density electroanatomic mapping can be useful in describing atrial tachycardia mechanisms and in determining successful sites for catheter ablation.

A 75-year-old woman with a history of prior ablation for persistent atrial fibrillation was referred for atrial tachycardia ablation. Based on her history and surface electrocardiogram P-wave morphology, a reentrant left atrial tachycardia was suspected. Isochronal late-activation mapping (ILAM) was performed during coronary sinus pacing using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ and EnSite™ NavX™ Precision cardiac mapping system, revealing a deceleration zone along the posterior left atrium with highly fractionated local signals **(Figures 1A and 1D)**. Following the induction of atrial tachycardia, local activation time mapping supported the diagnosis of left atrial reentrant tachycardia **(Figure 1B and Video 1)**. Entrainment was attempted; however, the tachycardia terminated repeatedly with catheter placement. Radiofrequency ablation was performed at this site along with isolation of the posterior wall. The pulmonary veins remained isolated from the previous procedure. The tachycardia was noninducible postablation, with no clinical recurrence at three months of follow-up.

This case highlights the utility of high-density mapping to accurately define tachycardia mechanisms and facilitate successful catheter ablation.

The authors report no conflicts of interest for the published content.
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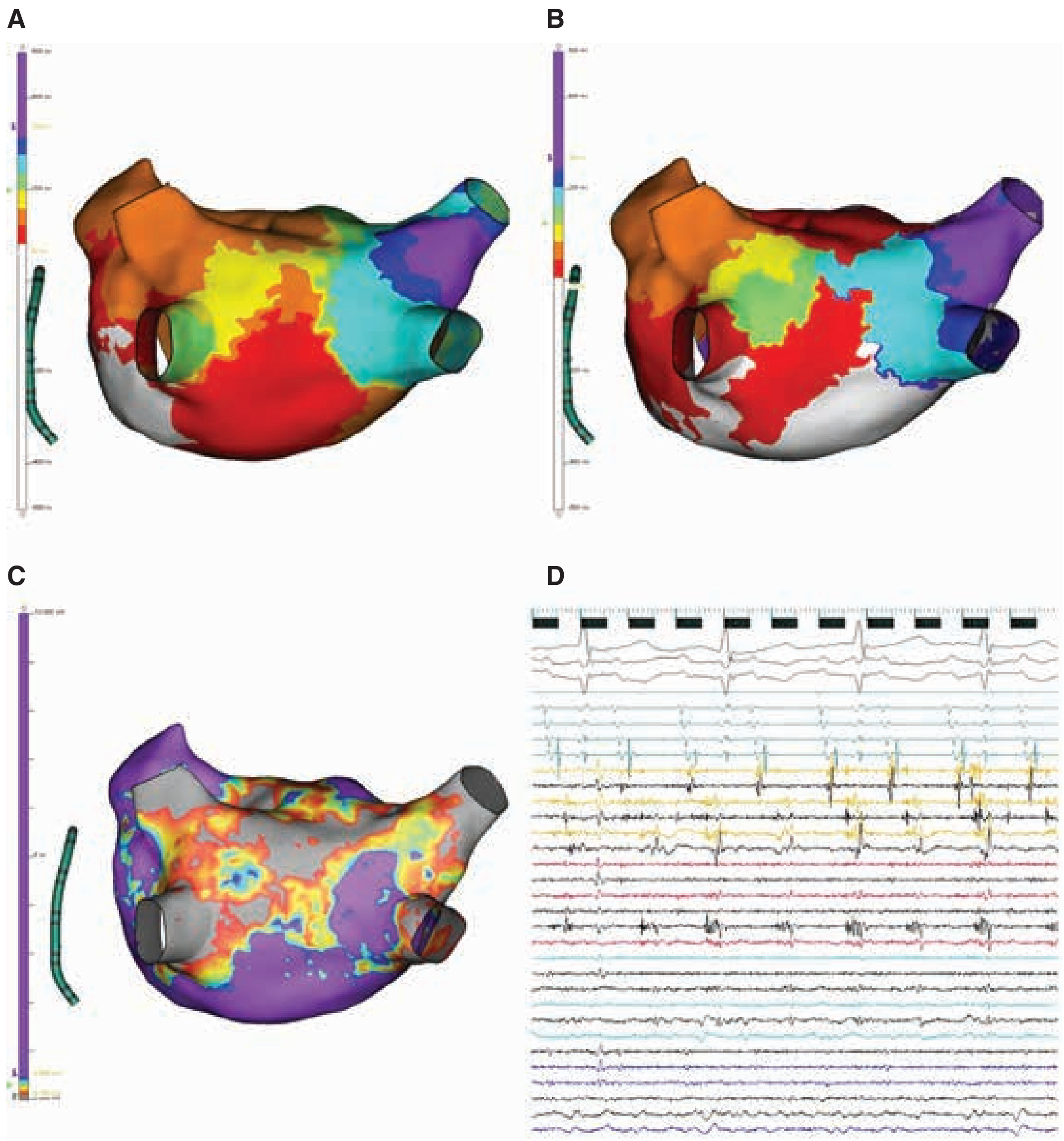

Figure 1: Left atrial electroanatomical maps and intracardiac electrograms. **A:** Isochronal late-activation map (ILAM) obtained during coronary sinus (CS) pacing. **B:** Local activation time during atrial tachycardia. **C:** Voltage map obtained during CS pacing. **D:** Intracardiac electrograms obtained using the Advisor™ HD Grid catheter at the site of termination during tachycardia, showing highly fractionated diastolic potentials.

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LEFT ATRIUM

Atypical Flutter with Atrial Isochronal Late-activation Map Correlating with the Critical Isthmus

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KEYWORDS. *Atrial isochronal late-activation mapping, atypical atrial flutter, critical isthmus.*

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Ablation of atypical atrial flutter is an increasingly challenging and prevalent problem. However, while induction of the arrhythmia is fundamental to the ablation strategy, this may not be universally possible. As an alternative, ultra–high-density mapping during sinus rhythm allows for the creation of isochronal late-activation maps (ILAMs) in patients with ventricular tachycardia and facilitates the identification of a critical isthmus even without induction of the ventricular arrhythmia. Creating an ILAM of the left atrium has not been systematically evaluated and it is not known whether additional ablation in these areas improves freedom from all atrial arrhythmias.

We report a case of left atrial mapping performed using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ in a patient referred for atypical atrial flutter ablation after prior pulmonary vein isolation. The arrhythmia could not be induced at the start of the case; subsequently, a left atrial map with high right atrial pacing was created and we identified a deceleration zone on the anterior left atrium **(Figure 1 and Video 1)**. Subsequent induction of the arrhythmia was possible and activation mapping suggested the previously identified region was the critical isthmus. Ablation in this region terminated the tachycardia. This case supports the validity of atrial ILAM as a strategy for the empiric ablation of atypical atrial flutter.

Dr. Kapur receives consulting fees/honoraria from Abbott, Medtronic, and Novartis.
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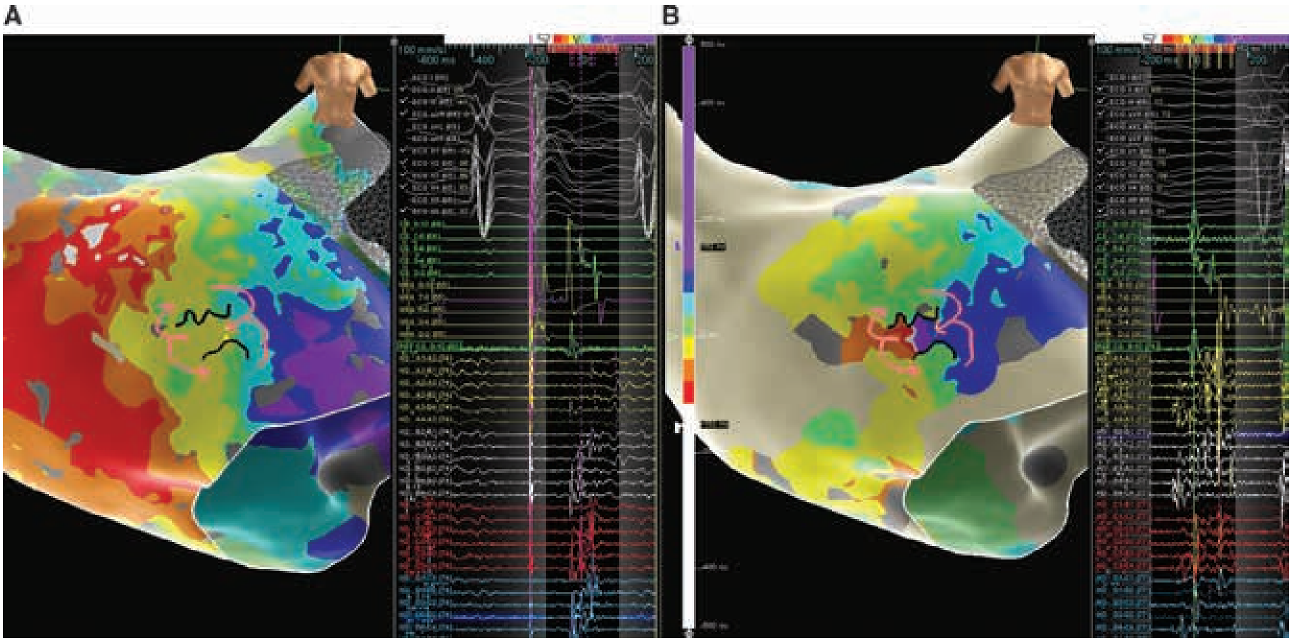

Figure 1: A: Atrial ILAM with right atrial pacing. **B:** ILAM of induced tachycardia.

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LEFT ATRIUM

Focal or Macro-reentrant (Dual-loop) Atrial Tachycardia? The Role of the Ligament of Marshall

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KEYWORDS. *Arrhythmogenic right ventricular cardiomyopathy, atrial tachycardia, left atrial appendage, ligament of Marshall.*

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A 56-year-old man was referred to our institution for cardiac ablation because of several episodes of palpitations and thoracic pain with an electrocardiogram suggestive for left atrial tachycardia (160 bpm). He was affected by arrhythmogenic right ventricular cardiomyopathy (ARVC) with left ventricular involvement and a plakophillin-2 gene mutation. A cardiac magnetic resonance imaging scan showed biventricular fibro-fatty infiltration with matching late gadolinium enhancement.

An electrophysiological study was performed in combination with electroanatomic mapping (EnSite Precision™). An activation map of the left atrium during tachycardia was created with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™. The region of earliest activation was identified at the base of the left atrial appendage (LAA), confirmed also by the EnSite™ LiveView Dynamic Display. The activation wavefront was suggestive for a focal-origin tachycardia from the LAA with an uncommon line of block between the LAA and left superior pulmonary vein along the left atrial roof **(Figure 1)**. However, we could not exclude a macro-reentrant (dual-loop) tachycardia **(Video 1)** with a slow-conduction isthmus inside the vein of Marshall with its fibrous and muscular component (Marshall bundle) as supported by the presence of fragmented potential along the line of block.

Ablation with 25 W (TactiCath™ Contact Force Ablation Catheter, Sensor Enabled™) at the earliest activation site terminated the tachycardia within three seconds. At six months of follow-up, no recurrence of the arrhythmia was observed.

Ms. Bonvicini and Mr. Indiani are employees of Abbott. The other authors report no conflicts of interest for the published content.
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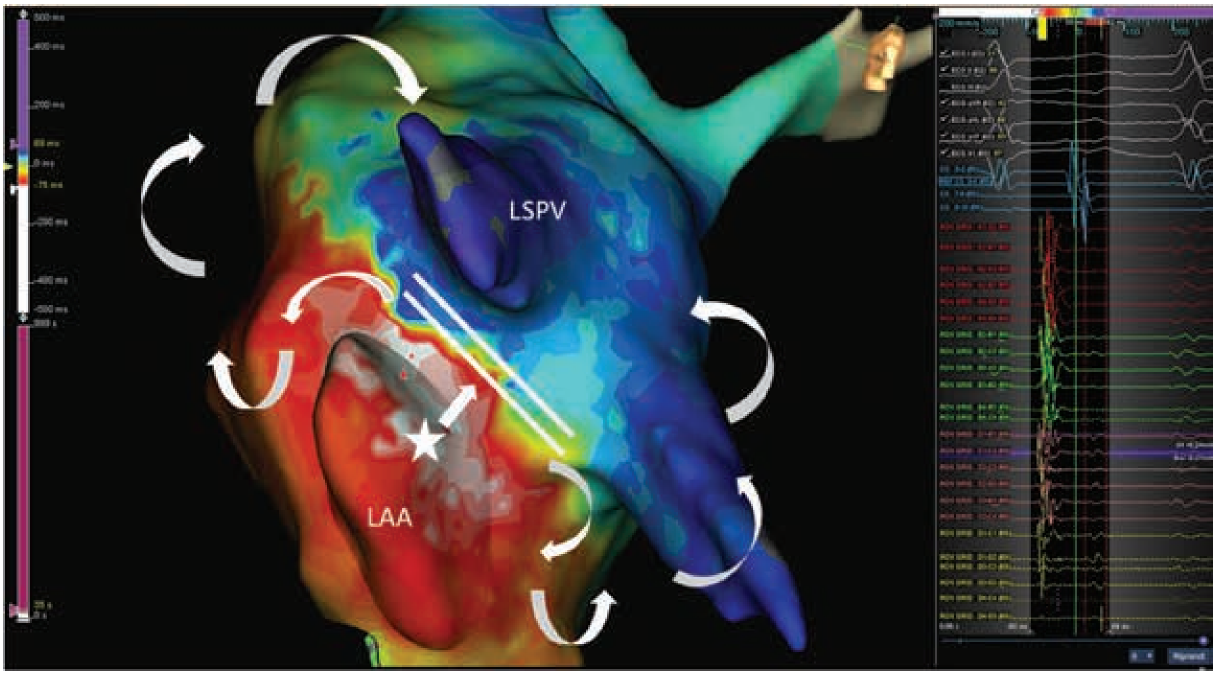

Figure 1: Left atrium activation mapping with the Advisor™ HD Grid Catheter. The activation wavefront was suggestive for a focal origin of tachycardia from the LAA with an uncommon line of block between the LAA and left superior pulmonary vein along the left atrial roof. LAA: left atrial appendage; LSPV: left superior pulmonary vein.

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LEFT ATRIUM

High-density Grid Catheter Localizes Eccentric Atrial Flutter to the Left Superior Pulmonary Vein Ridge Through Extreme Isochronal Compression

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KEYWORDS. *High-density grid, high-density mapping, left atrial flutter, left atrial ridge, localized reentry.*

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A 75-year-old woman with hypertension and symptomatic drug-refractory paroxysmal atrial fibrillation (AF) elected to undergo AF ablation. Pulmonary vein isolation was performed with a wide antral circumferential ablation. As her esophagus was bordering the left-sided ostia and our left-sided ablation lesion set was more antral, we were also able to isolate her posterior wall. Rapid atrial pacing postablation induced an eccentric atrial flutter (AFL) with a cycle length of 260 ms. Activation mapping with the EnSite Precision™ mapping system with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ catheter revealed localized reentry at the left atrial appendage/left superior pulmonary vein ridge. At the critical location, significant compression was seen on the activation color map with a fractionated signal with a duration of 190 ms, essentially encompassing two-thirds of the tachycardia cycle length **(Figure 1 and Video 1)**. Ablation at this region terminated the AFL within a few seconds and the AFL was no longer inducible postablation. This case demonstrates the use of the high-resolution Advisor™ HD Grid catheter using high-density wave technology to analyze orthogonal electrograms at a single location, thereby facilitating rapid identification and treatment of AFL.

Mr. Racette and Ms. Wrobel are employees of Abbott. The other author reports no conflicts of interest for the published content.
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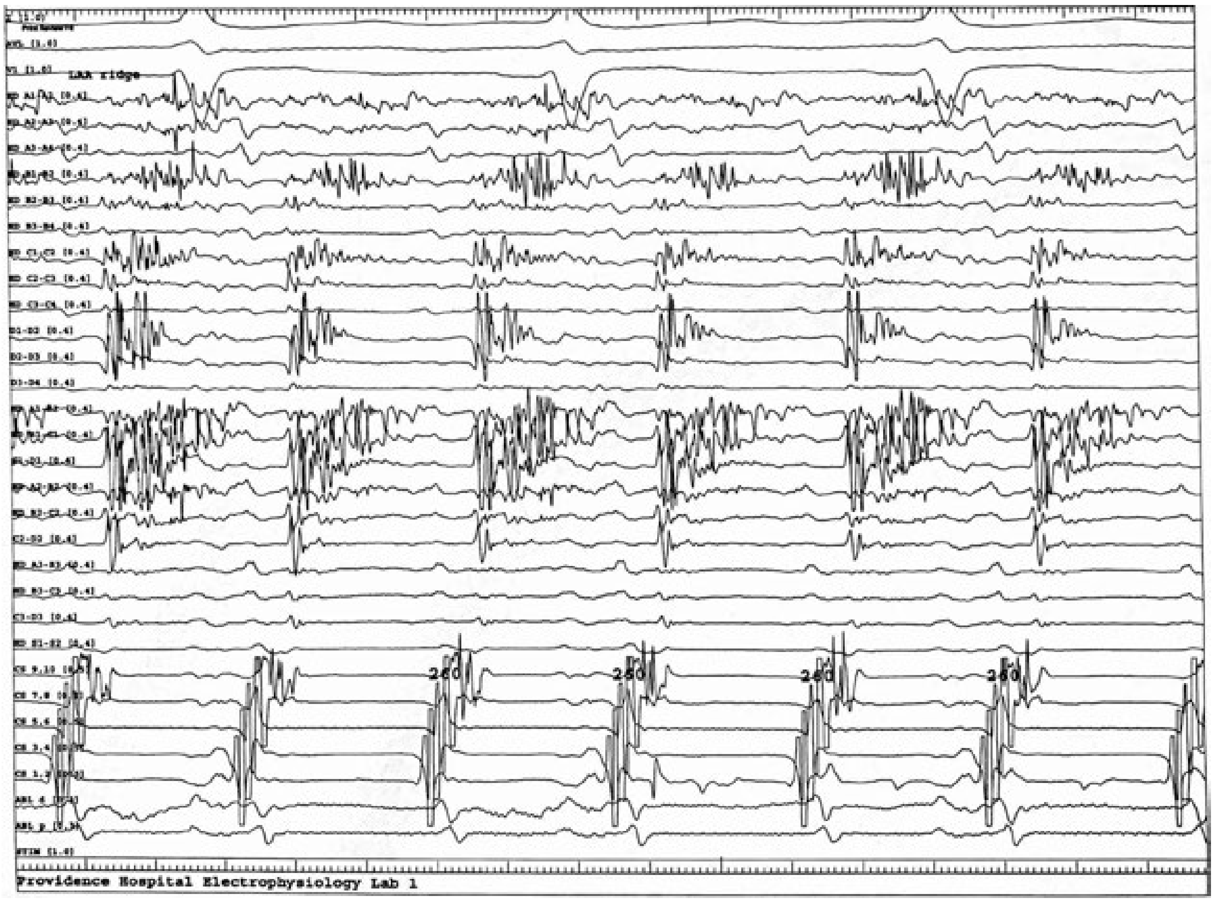

Figure 1: Intracardiac tracing illustrating ~70% of the tachycardia cycle length observed with Advisor™ HD Grid bipole in the left atrial appendage/left superior pulmonary vein ridge.

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LEFT ATRIUM

Accurate Identification of Reentrant Circuit and Critical Isthmus of an Atrial Tachycardia Over the Posterior Wall of the Left Atrium Requiring a 1.4-second Single Radiofrequency Energy Application

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KEYWORDS. *Atrial tachycardia, high-density mapping, radiofrequency ablation, repeat ablation.*

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A 61-year-old man with longstanding persistent atrial fibrillation (AF) since 2010 presented to the clinic, having undergone cardioversion for AF in 2016 and AF ablation (pulmonary vein isolation, posterior left atrium isolation, and cavotricuspid isthmus ablation) in July 2017. He developed atrial tachycardia (AT) a few months after the AF ablation procedure and underwent AT ablation (LA posterior wall) in October 2017. However, he experienced early recurrence, requiring a second cardioversion (for AT) and treatment with dofetilide in 2018. He remained primarily in sinus rhythm until September 2020, when he developed persistent AT again, which recurred after a third cardioversion attempt in early October 2020.

In late October 2020, the patient underwent repeat AT ablation using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™, which confirmed macro-reentrant AT originating from the posterior wall of the left atrium **(Video 1)**. A very narrow isthmus was identified precisely; delivery of one radiofrequency energy application with 35 W of power terminated the tachycardia in 1.4 seconds.

However, postablation mapping showed scattered areas of live tissue over the posterior wall communicating with the left atrium. Mapping with the Advisor™ HD Grid catheter was able to identify the reentrant circuit accurately and further ablation was performed in sinus rhythm to achieve complete isolation of the posterior wall. In addition, all remaining potentials were eliminated, having been missed using other catheters during the previous two ablation sessions. Isolation persisted after 30 minutes of observation and the infusion of isoproterenol during the postablation period.

Dr. Hrachian reports the reception of research grants from Abbott and is also consultant for Abbott. Ms. Juliana Rios is an employee of Abbott. Both authors report no equity relationship with Abbott.
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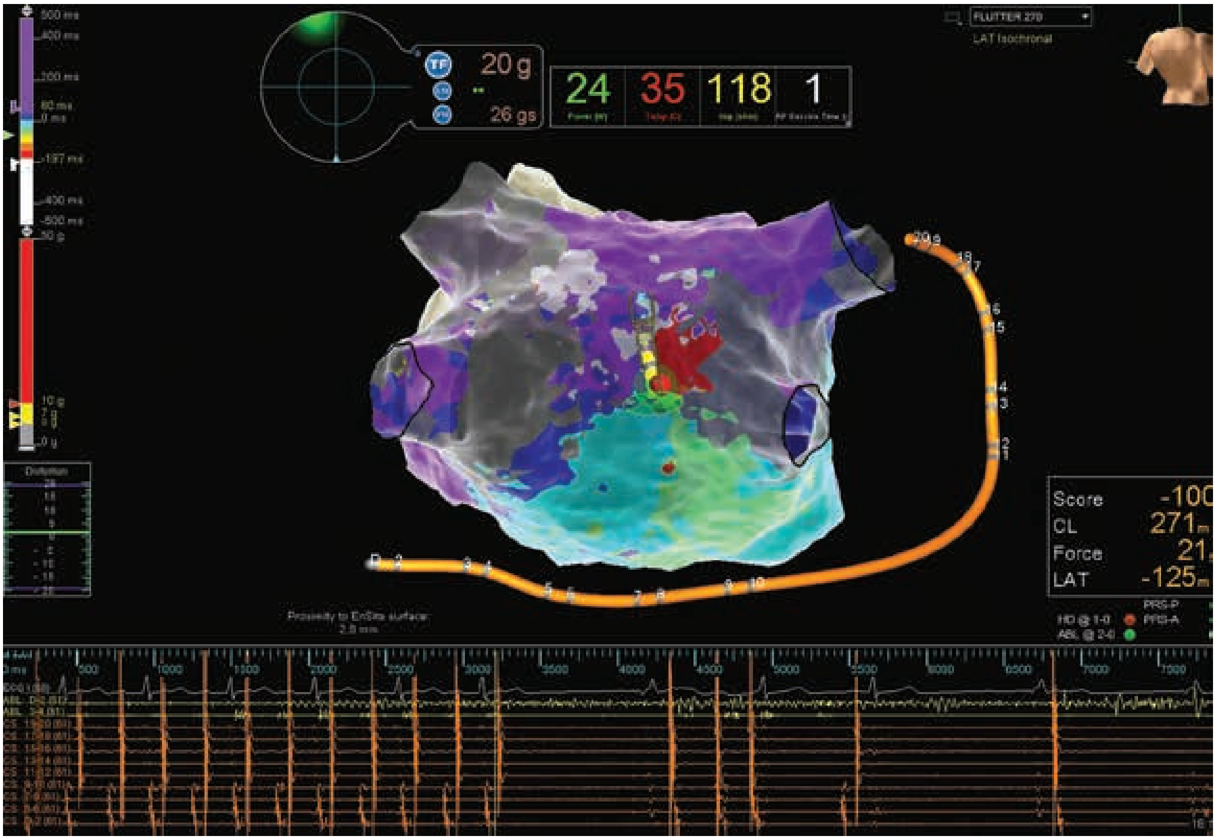

Figure 1: Left atrial posterior wall.

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LEFT ATRIUM

High-density Grid Mapping of Micro- and Macro-reentrant Left Atrial Arrhythmias

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KEYWORDS. *Atypical atrial flutter, focal atrial tachycardia, high-density grid, micro-reentrant atrial tachycardia.*

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A 69-year-old woman with a history of heart failure with preserved ejection fraction and atrial fibrillation and flutter presented with recurrent palpitations. Prior radiofrequency ablation included left atrial pulmonary vein (PV) isolation, roof line, posterior mitral line, and right atrial cavotriscupid isthmus line. She was found to be in atypical atrial flutter consistent with a left atrial origin based on surface P-wave morphology [(−) I, aVL; (+) II, III, aVF; (+) V1–6] **(Figure 1)**.

Repeat radiofrequency ablation was performed, including three-dimensional electroanatomical and activation-sequence mapping using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ to identify both micro-reentrant and macro-reentrant left atrial arrhythmias. First, the presenting rhythm was atypical atrial flutter with a cycle length (CL) of 275 ms, proximal-to-distal coronary sinus activation, and centrifugal spread consistent with a focal origin of the tachycardia from the left atrial roof adjacent to the right superior PV. Atrial electrograms at the proposed site of origin were low-amplitude, fractionated, and spanning nearly 100% of the tachycardia CL within the 1.3 × 1.3-cm high-density grid footprint **(Figures 2 and 3)**. Entrainment from this site yielded a postpacing interval minus the tachycardia CL of 5 ms, consistent with a micro-reentrant mechanism.

Next, radiofrequency ablation was delivered at the target site, resulting in transformation to a second atypical atrial flutter with a CL of 355 ms, which was determined to be a perimitral macro-reentrant flutter using high-density grid activation mapping **(Figure 4)** and entrainment. Formation of an anterior mitral line from the anterior mitral annulus to the anterior right superior PV terminated the arrhythmia **(Figure 5)**. Differential pacing maneuvers confirmed block across the anterior mitral isthmus line, roof line, and cavotricuspid isthmus and PV isolation. There were no immediate complications and the patient was discharged home the next day in sinus rhythm.

Acknowledgments

The authors would like to thank Kristin Pallister of Abbott for her support mapping during the case and for providing images for this report.

Dr. Wan has served on the steering committee for Medtronic and Boston Scientific. Dr. Saluja has served as a consultant to Abbott and BioSense Webster. Dr. Biviano has served as a medical advisory board member for Abbott, BioSense Webster, and Boston Scientific. The other authors report no conflicts of interest for the published content.

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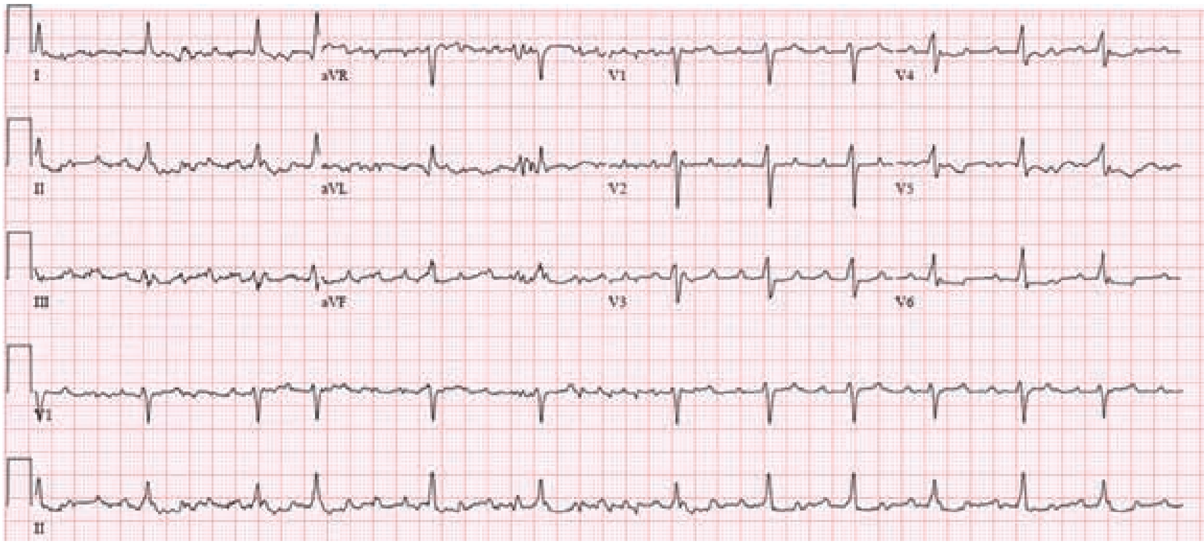

Figure 1: Twelve-lead electrocardiogram of the clinical tachycardia.

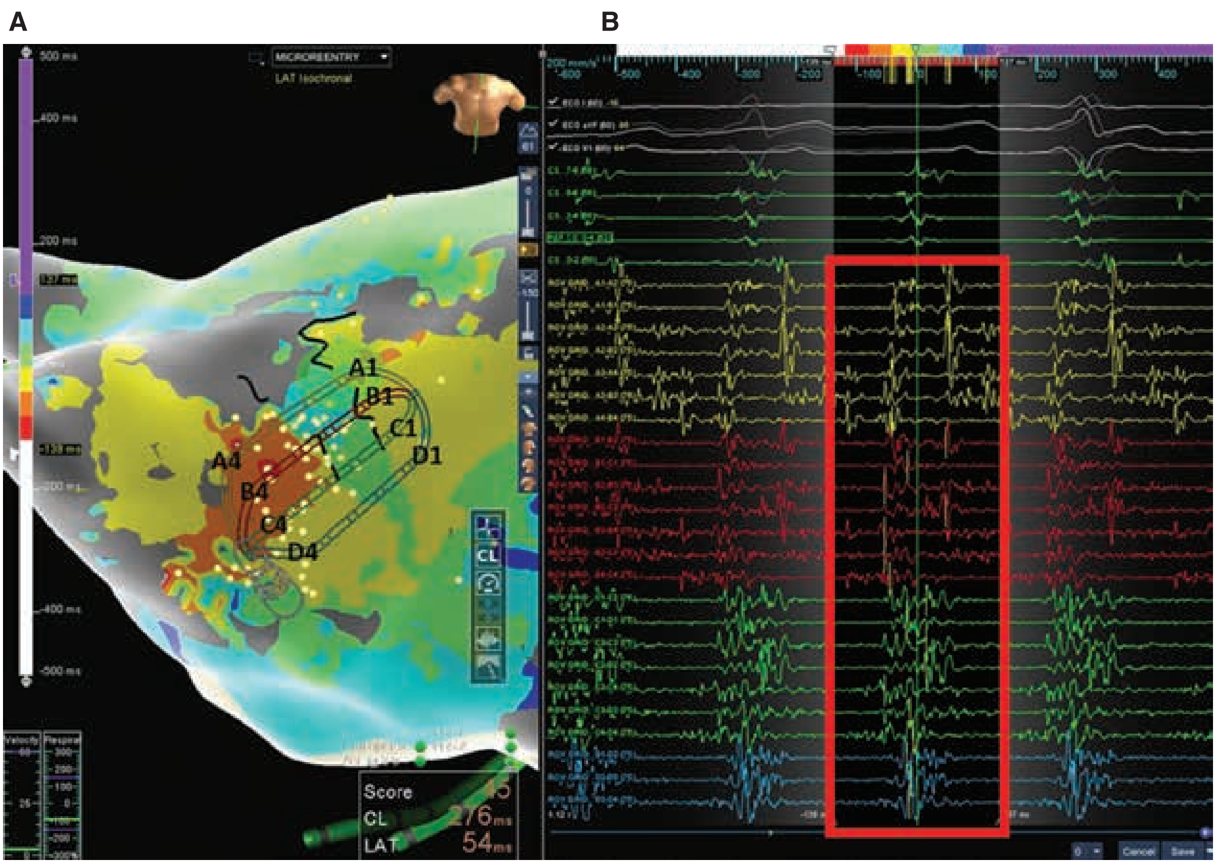

Figure 2: A: Left atrial isochronal activation map (modified anteroposterior view tilted inferiorly) of atypical atrial flutter no. 1 (CL: 275 ms) acquired with the Advisor™ HD Grid mapping catheter. Note the presence of six of eight isochrones (> 75% CL) within the 1.3 × 1.3-cm footprint of the Advisor™ HD Grid catheter located on the left atrial roof adjacent to the right superior PVs. The area between the black lines of block is a proposed isthmus for the micro-reentrant circuit with centrifugal spread. **B:** Corresponding electrograms from the Advisor™ HD Grid mapping catheter in this location showing low-amplitude, fractionated signals encompassing 75% to 100% of the CL.

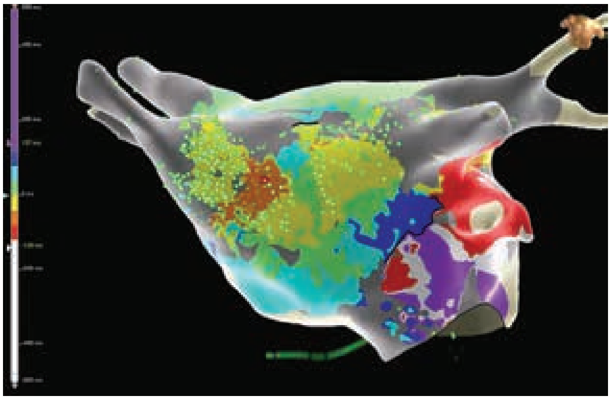

Figure 3: Still frame from the left atrial (modified anteroposterior view tilted inferiorly) sparkle map **(Video 1)** superimposed on an isochronal activation map of atrial tachycardia no. 1 acquired with the Advisor™ HD Grid mapping catheter showing the likely path of the micro-reentrant circuit on the left atrial roof adjacent to the right superior PV.

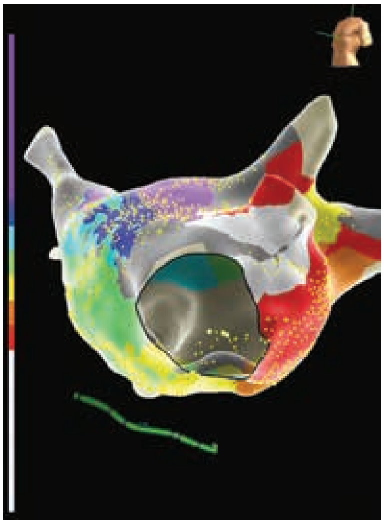

Figure 4: Left atrial (left anterior oblique view) activation map of atrial flutter no. 2 acquired with the Advisor™ HD Grid mapping catheter showing perimitral macro-reentrant flutter.

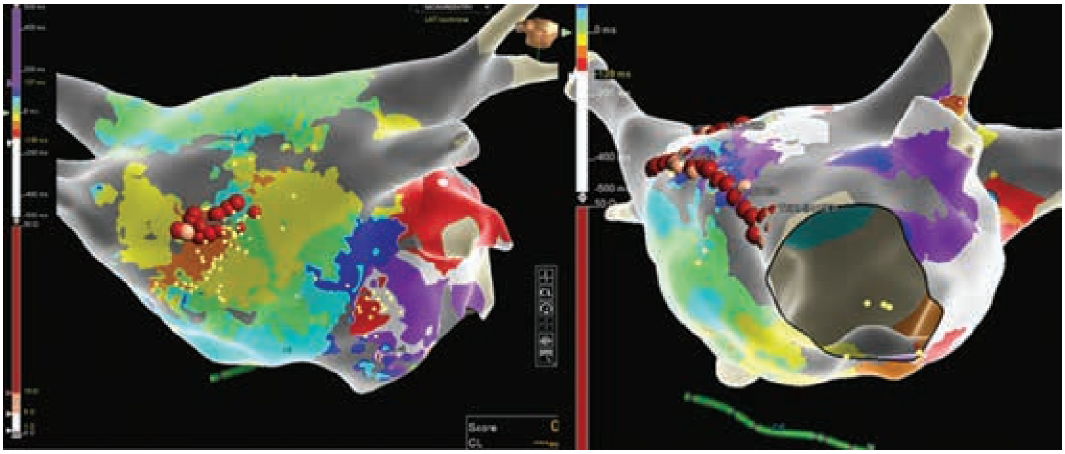

Figure 5: A: Left atrial (modified anteroposterior view tilted inferiorly) activation map of atrial flutter no. 1. The pink and red dots are the ablation lesions. **B:** Left atrial (left anterior oblique view) activation map of atrial flutter no. 2. The pink and red dots are the ablation lesions.

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LEFT ATRIUM

High-density Grid Use for Left Lateral Accessory Pathway

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KEYWORDS. *Advisor HD Grid, accessory pathway, AVRT, first burn termination, TactiCath sensor-enabled contact force ablation catheter.*

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A 49-year-old woman with multiple documented episodes of narrow QRS complex tachycardia underwent electrophysiology study at our hospital. Baseline ventricular pacing demonstrated eccentric retrograde coronary sinus activation consistent with a left lateral accessory pathway **(Figure 1A)**. Orthodromic tachycardia using a left lateral accessory pathway was repeatedly induced.

Transseptal puncture allowed access to the left atrium and left ventricle, where high-density mapping was performed across the mitral valve anulus during ventricular pacing using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ and the EnSite Precision™ electroanatomic mapping system to localize the concealed left lateral accessory pathway. The open-window mapping technique[1] was used by collecting the absolute dV/dt bipolar electrogram from the high-density grid to help distinguish the mitral valve anulus, collecting both atrial and ventricular electrograms to delineate functional block located at the valve plane **(Figure 1B)**. At the location of the accessory pathway, bipolar fusion and pathway potentials recognized and annotated on the high-density grid were able to showcase the atrial insertion point of the accessory pathway **(Figures 1B and 1C)**. Additionally, during ventricular pacing and, similarly, during orthodromic supraventricular tachycardia, EnSite Precision™ open-window propagation and, in particular, the SparkleMap™ display feature **(Figures 2A and 2B)** allowed for more precise localization of the atrial insertion of the bypass tract by dynamically displaying wavefront propagation superimposed on top of the local activation timing and voltage maps **(Videos 1 and 2)**.

Ablation was performed with the TactiCath™ Contact Force Ablation Catheter, Sensor Enabled™ at a power of 30 W and a minimal contact force of 10 g while the patient was in orthodromic supraventricular tachycardia. The tachycardia was terminated with a single lesion delivered to the mitral valve annulus at the atrial insertion site, subsequently eliminating the accessory pathway **(Figure 1E)**. A thorough waiting period and electrophysiology study showed no evidence of accessory pathway conduction and the patient has remained symptom-free during follow-up.

Ms. Paskman and Ms. Hammond are employees of Abbott. The other authors report no conflicts of interest for the published content.
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Reference

1. Schricker AA, Winkle R, Moskovitz R, et al. Open-window mapping of accessory pathways utilizing high-density mapping. *J Interv Card Electrophysiol.* 2020 Aug 13. [Epub ahead of print].

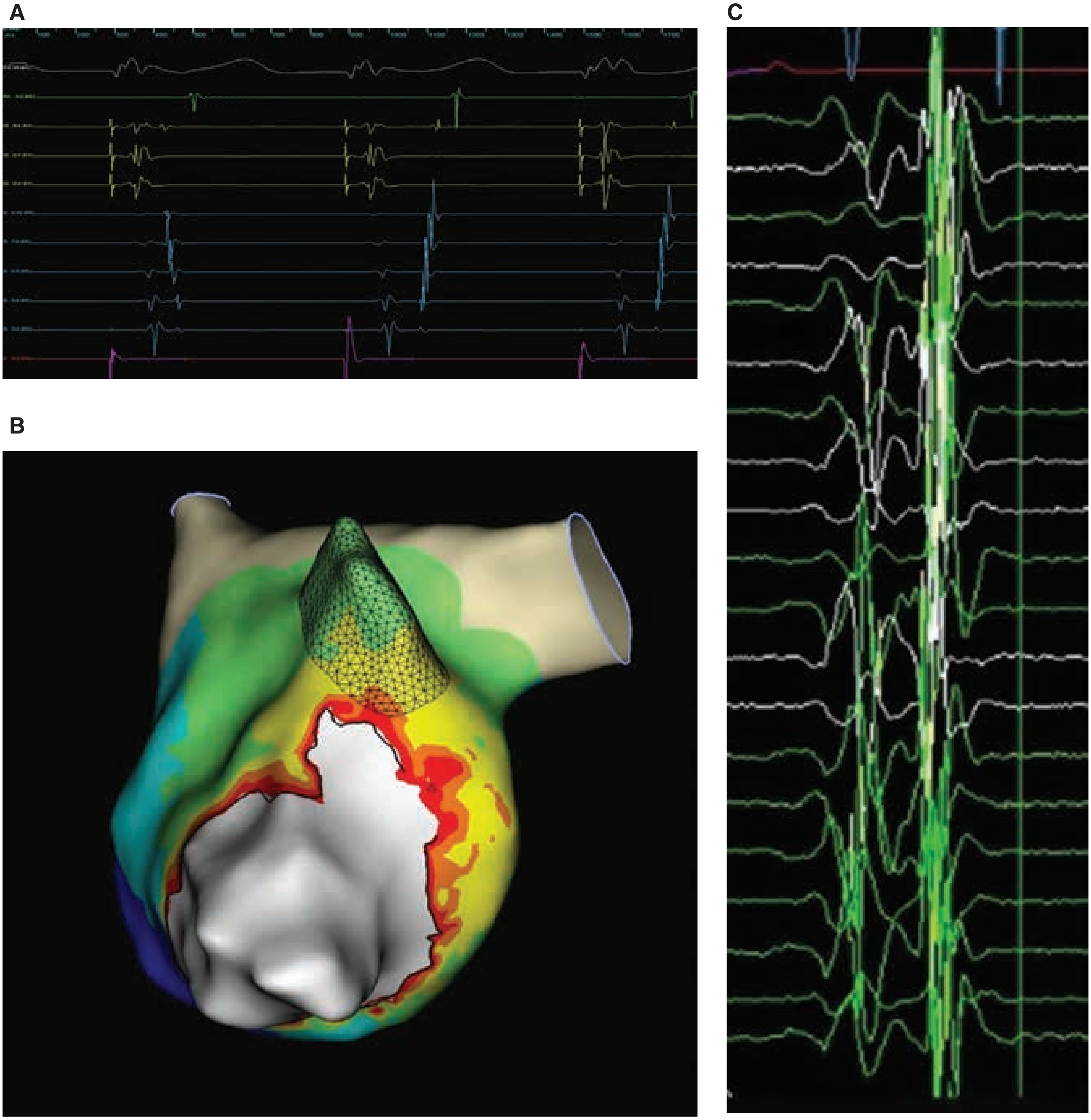

Figure 1: A: Ventricular pacing showcasing retrograde activation switching from atrioventricular nodal to accessory pathway conduction. **B:** EnSite Precision™ open window map of the left lateral accessory pathway using the Advisor™ HD Grid catheter. **C:** Advisor™ HD Grid electrogram at the left lateral pathway location.

Figure 1: D: Clinical tachycardia 12-lead presentation. **E:** First burn termination during supraventricular tachycardia with the TactiCath™ contact force catheter. **F:** Ventriculoatrial fusion at the site of successful ablation on the pathway.

A

B

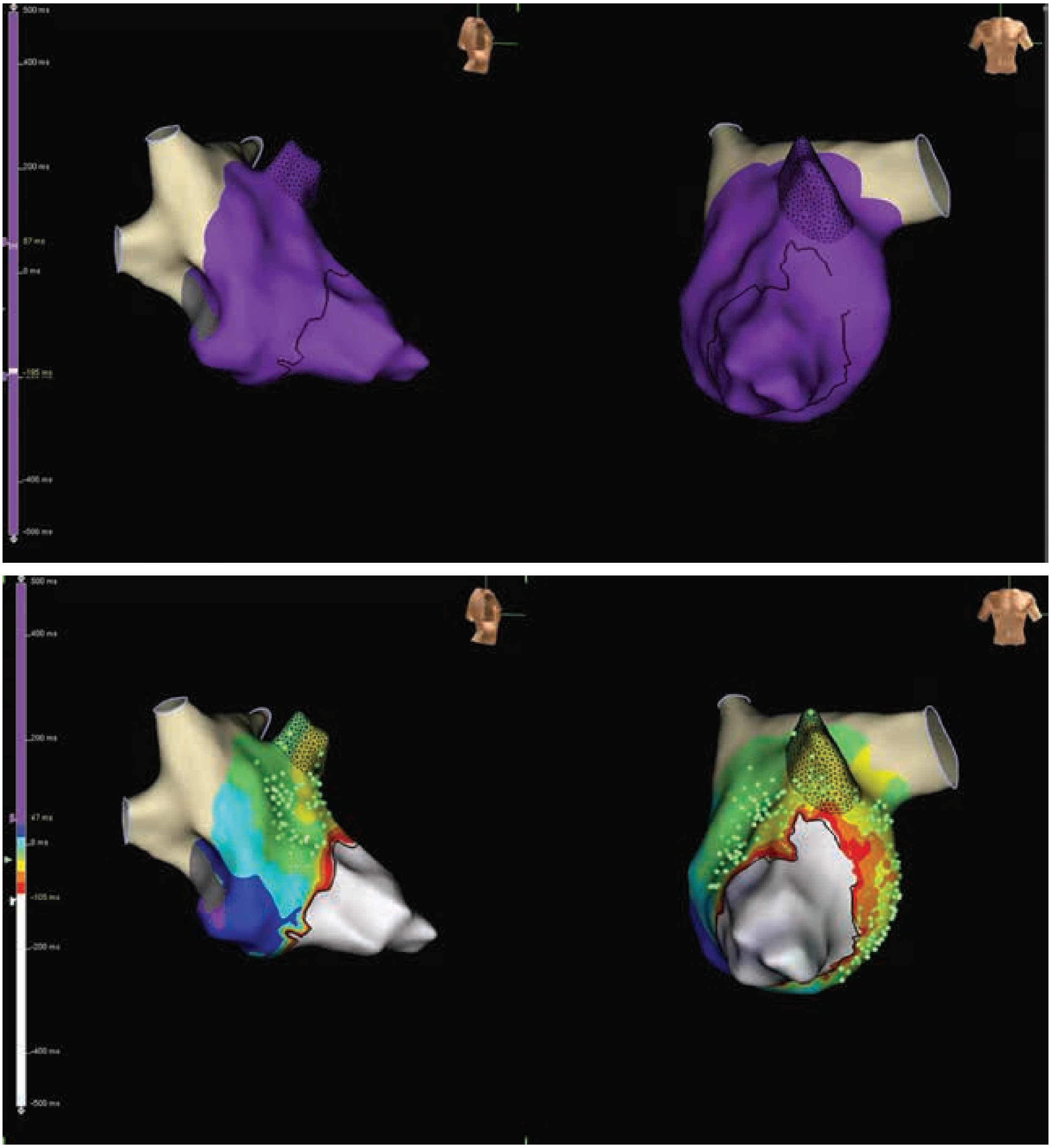

Figure 2: A: EnSite Precision™ open-window propagation video of the left lateral accessory pathway. **B:** EnSite Precision™ open-window map of the left lateral accessory pathway displayed with SparkleMap™.

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LEFT ATRIUM

Map of Prolonged Electrogram Duration to Guide Atrial Substrate Ablation for Atrial Fibrillation Recurrence Following Durable Pulmonary Vein Isolation

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KEYWORDS. *Complex fractionated atrial electrograms, electrogram duration, functional substrate, persistent atrial fibrillation, voltage map.*

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Pulmonary vein isolation (PVI) is considered an appropriate therapeutic strategy for persistent atrial fibrillation (AF) (PAF) even if less effective than that for paroxysmal AF. The recurrence of PAF depends upon the extent, localization, and degree of atrial tissue damage. Performing an atrial tissue substrate study is highly desirable in patients with PAF, especially in cases of recurrence after PVI, to improve the ablation outcome.

We describe a patient (55 years old) affected by highly symptomatic PAF who underwent PVI. After four months, despite antiarrhythmic drug therapy, the patient experienced PAF recurrence and a second intervention was planned. During the intervention, an external electric cardioversion was firstly performed to restore sinus rhythm (SR). Voltage mapping (0.1–0.5 mV) during SR demonstrated no areas of low voltage.

The procedure was performed using the EnSite Precision™ cardiac mapping system and the multipolar diagnostic Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ **(Video 1)**. Voltage and atrial electrogram duration maps (AEDUM method) were created by using the EnSite Precision™ AutoMap™ mapping tool.

Bipole electrogram (EGM) durations were measured using the Ensite Precision™ TurboMap™ tool, which allowed us to review SR maps and calculate the duration of each point as the temporal distance (ms) between the first and last deflections of each endocardial EGM. A high-density wave configuration reduced the limitation of angle variance between the bipole pair and wavefront propagation **(Figure 1)**. A cutoff of 45 ms for EGM duration was applied based on our previous experience of left atrium mapping in subjects without a history of AF (unpublished data). The area with slow and inhomogeneous conduction was ablated, applying a power level of 40 W, with guidance provided by the lesion index. The patient remained free from recurrence after eight months of clinical follow-up.

The proposed approach could allow operators to tailor the ablation scheme for each patient depending on the location and extension of areas with slow conduction. In this case, the roof and the anterior regions were involved instead of the posterior wall.

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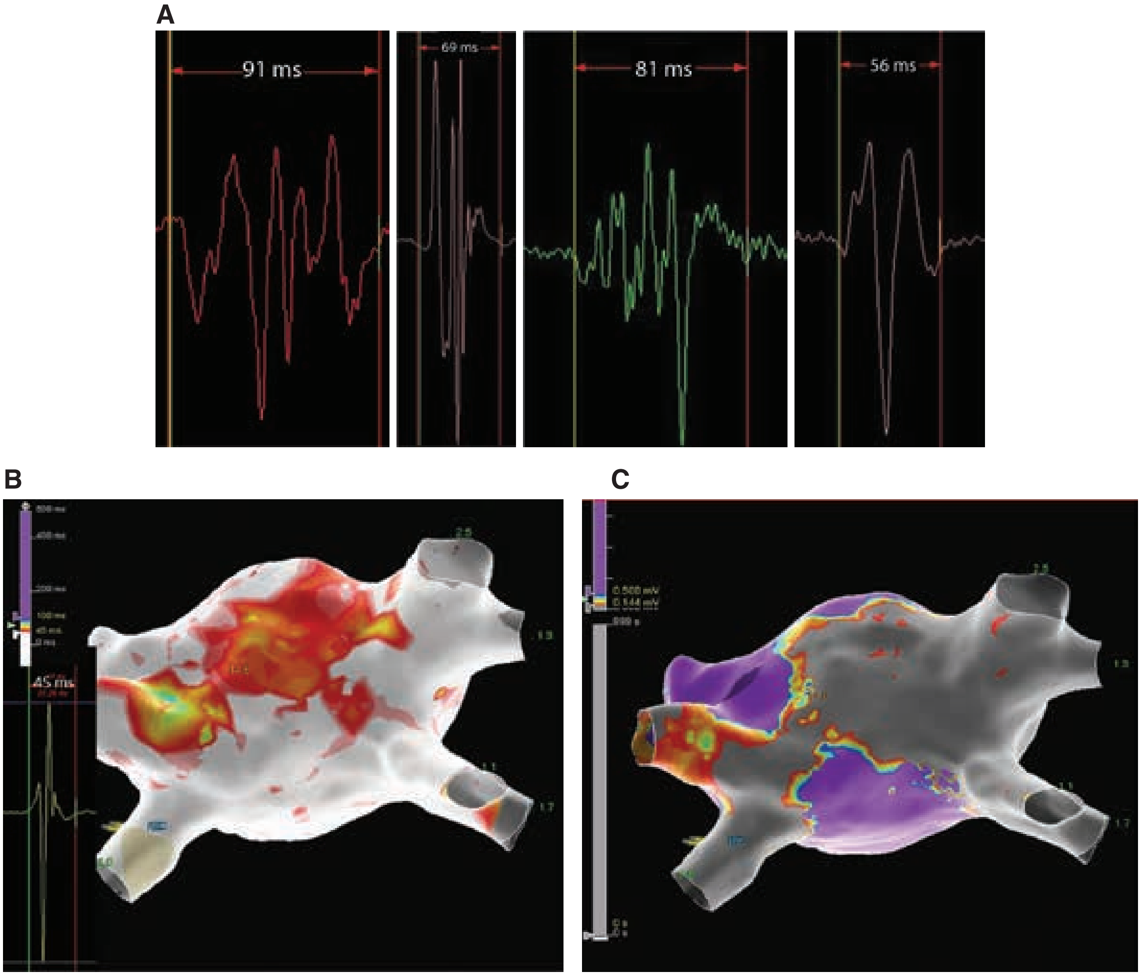

Figure 1: A: Representative prolonged EGMs recorded in the roof and anterior region of the left atrium during SR using the Advisor™ HD Grid diagnostic catheter. **B:** Three-dimensional left atrium map with an area of prolonged EGMs as a marker of slow and inhomogeneous conduction. **C:** Voltage map view indicating the extension of the atrial ablation involving the red area with conduction abnormalities shown in **B**.

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LEFT ATRIUM

A Tailored Approach to the Ablation of Atrial Fibrillation in Rheumatic Valvular Disease with High-density Grid Technology

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KEYWORDS. *Ablation, Advisor HD Grid, atrial fibrillation, high-density mapping.*

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Atrial fibrillation (AF) ablation can be particularly challenging in the setting of valvular rheumatic disease due to the organic structural alterations of the left atrium (LA) inherent with this condition. The use of high-density (HD) maps can improve the operator's ability to target the arrhythmia with a tailored approach, especially in complex cases.

We report the case of a 64-year-old female patient with rheumatic severe mitral regurgitation treated by mitral valve prosthetic ring annuloplasty. We performed AF ablation using the EnSite™ Precision™ mapping system; the multipolar Advisor™ HD Grid Mapping Catheter, Sensor Enabled™; and the EnSite™ LiveView software tool, which allows dynamic "beat-to-beat" activation and voltage-mapping visualization. HD mapping (39.070 points) performed during AF showed low voltage (LV) spread throughout the entire LA, so we conducted synchronized electrical cardioversion. The new HD map (26.821 points) was completely different, showing some areas of the anterior and septal walls with voltages of greater than 0.6 mV (purple color indicating normal tissue in **Figure 1**) alternating with areas of LV of less than 0.3 mV (grey color indicating scar tissue in **Figure 1**), while the remaining areas of the LA were mostly healthy (purple color). We performed complete posterior vein isolation and posterior wall isolation **(Video 1)**. No lesions were created in the remaining anatomical region in order to leave as much healthy tissue as possible. At five months of follow-up, no AF recurrence was documented.

In our case, we constructed very HD maps (> 25,000 points acquired) using omnipolar technology; this approach proved to be insensitive to catheter orientation unlike the bipolar mapping and supported us in the attempt to perform a "true tailored" ablation, helping us to save the anatomical areas characterized by healthy tissue and focus on only the substrates that probably would not be identified with bipolar HD mapping. HD mapping with the use of an omnipolar catheter, especially in a very complex scenario like rheumatic valvular disease, represents a fundamental tool with which to precisely search AF substrates and tailor the ablation strategy.

Mr. Zonno is an employee of Abbott. The other authors report no conflicts of interest for the published content.
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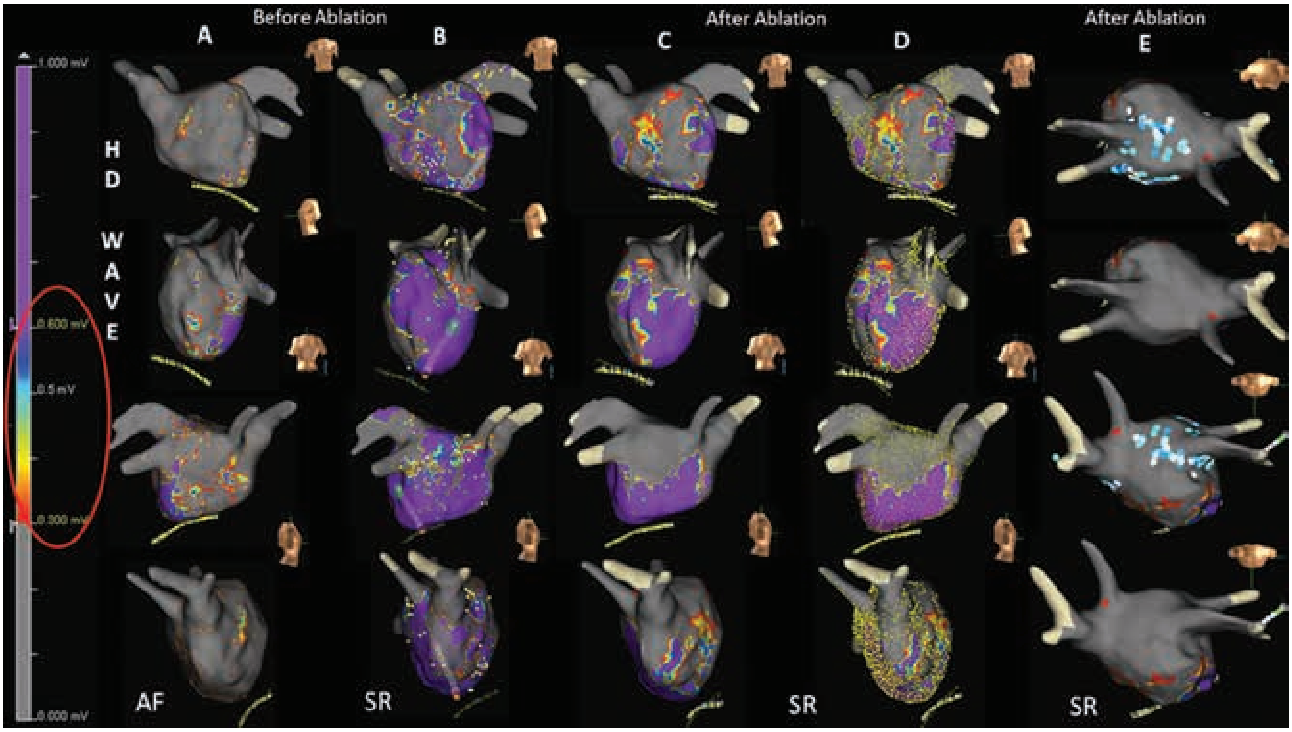

Figure 1: LA HD voltage maps acquired using the multipolar Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ and the EnSite™ Precision™ mapping system in an HD-wave configuration using the voltage range of 0.3 to 0.6 mV. **A:** Map recorded before ablation with 39.070 points acquired during AF showing an LV of less than 0.3 mV that affected most of the LA, compatible with scar tissue (grey color). **B:** Map recorded before ablation during sinus rhythm showing the prevalence of voltages of greater than 0.6 mV (purple color), compatible with normal tissue in most of the LA. **C:** Map recorded after ablation demonstrating the strategy adopted to treat only areas of the posterior and anterior walls of the LA presenting LV in the range of 0.3 to 0.6 mV, as a set of different colors, possibly indicative of patchy fibrosis. **D:** Maps showing the number of points acquired (> 25,000), evenly distributed over the entire left atrial volume. **E:** Cranial projections of the map after ablation clearly demonstrating complete isolation of the pulmonary veins and posterior wall.

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RIGHT VENTRICLE

First-in-Man Rapid, Ultra–high-resolution Mapping of the Outflow Tracts Using the Advisor™ HD Grid Catheter

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KEYWORDS. *Catheter ablation, premature ventricular complex, right ventricular outflow tract, high-density grid mapping.*

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A 65-year-old man without structural heart disease was referred for catheter ablation of highly symptomatic bigeminal, monomorphic premature ventricular complexes (PVCs) believed to be originating from the left ventricular outflow tract (LVOT) (**Figure 1,** panel A). High-density activation mapping was performed using the EnSite™ NavX™ mapping system. PVCs were 15 ms pre-QRS (**Figure 1,** panel A, left column) in the distal coronary sinus and proximal anterior interventricular vein as mapped using a decapolar mapping catheter (Inquiry™). A novel paddle-shaped, high-resolution multipolar catheter (Advisor™ HD Grid), maneuvered to the coronary cusps via a retrograde aortic approach, demonstrated earliest activation in the aortic cusps at the right coronary cusp, 19 ms pre-QRS (**Figure 1,** panel A, middle column and panel D). The septal/free wall of the RVOT demonstrated activation 32 ms pre-QRS (**Figure 1,** panel A, right column; panel B; and panel E). Ablation was performed to the earliest RVOT activation site with immediate cessation of ectopy and consolidative lesions applied (**Figure 1,** panels C and F). Further consolidative lesions were also applied in the right coronary cusp at its earliest site. No immediate complications were recorded and the patient showed no recurrence at six weeks of follow-up. Activation mapping included 350 mapping points collected within 218 seconds of mapping time.

The novel Advisor™ HD Grid catheter is a high-density, 7-French mapping catheter with a paddle configuration with 18 1-mm-wide electrodes arranged in a 4 × 4 configuration with a 3-mm edge-to-edge separation (**Figure 1,** panel G). To our knowledge, this is the first description of its successful use for rapid, ultra–high-resolution activation mapping in the outflow tracts, allowing for differentiation of site of origin and successful ablation eventually in the septal/free wall RVOT despite ECG morphology suggestive of an LVOT origin. The catheter was safe, easily maneuverable in the cusps, and facilitated high-density electroanatomic definition of the cusps.

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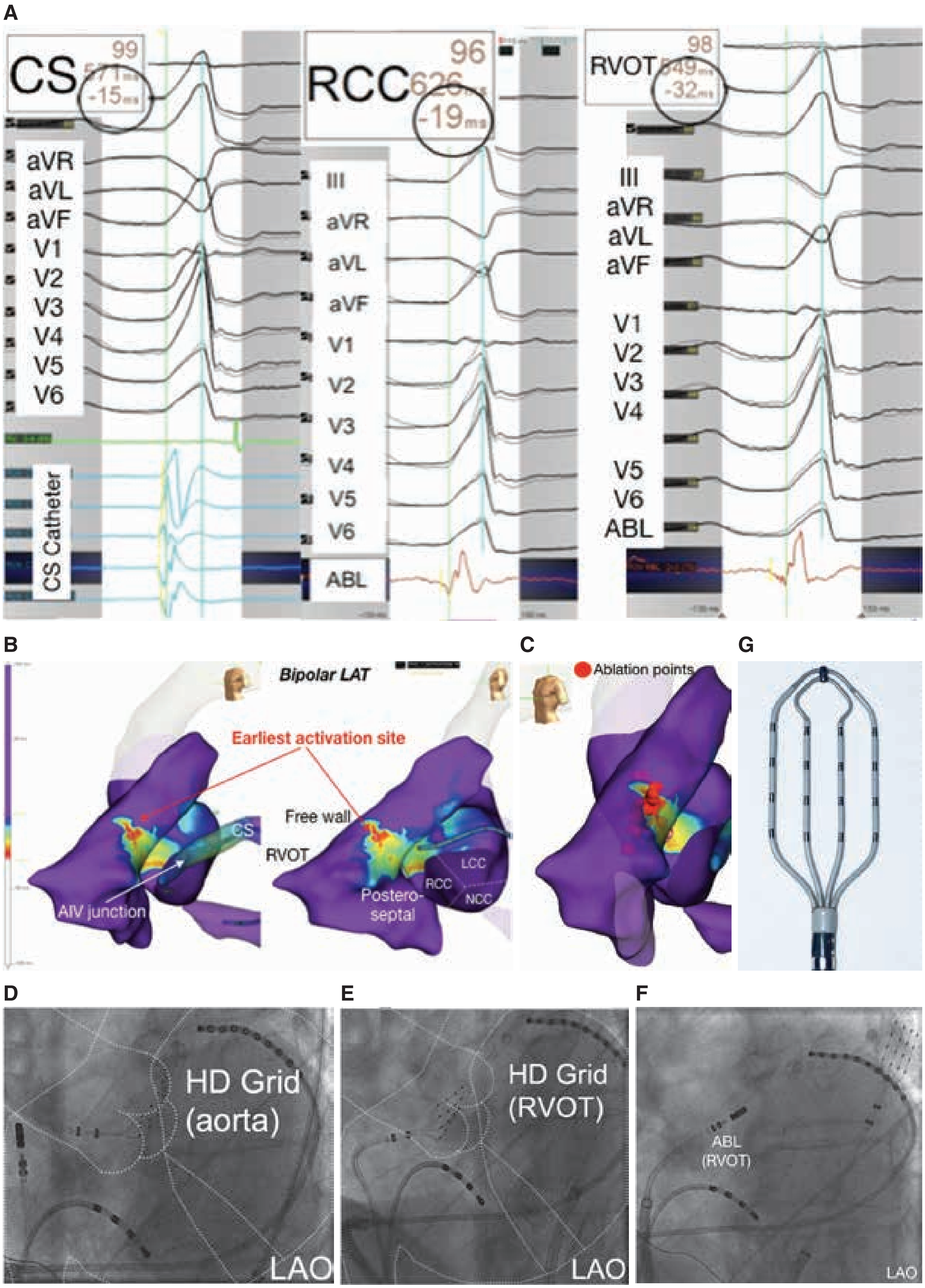

Figure 1: A: The clinical PVC and earliest signals from the CS, RCC and RVOT sites. **B:** The LAT map demonstrating the earliest zone, 32 ms pre-QRS, seen in the RVOT. **C:** Ablation lesions. **D–F:** Ablation-associated fluoroscopic images of the Advisor™ HD Grid catheter positioned in the LVOT and RVOT. **G:** Catheter design of the Advisor™ HD Grid catheter.

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RIGHT VENTRICLE

Single-application Radiofrequency Interruption in a Broad Isthmus Ventricular Tachycardia by Targeting the Longest Electrogram Visualized Using a New Customized Software (VEDUMap)

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KEYWORDS. *Slow conduction, VEDUMap, ventricular tachycardia ablation.*

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A 63-year-old woman with a diagnosis of arrhythmogenic right ventricular cardiomyopathy was referred to our department for recurrent monomorphic ventricular tachycardia (VT) with left bundle branch block and intermediate axis. A previous endocardial procedure was ineffective. After pericardial access, a detailed electroanatomical sinus rhythm map was obtained to verify areas of slow conduction and local abnormal ventricular activation **(Figure 1B)**. A confined spot of late potentials (LPs) was detected in an inferolateral aneurism. A marked deceleration zone in sinus rhythm was revealed at the base of the apex of the spot of LPs. VT was induced with a single extrastimulus and the full cycle length was recorded in the epicardium by the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ using the HD Wave acquisition algorithm **(Figure 1A)**. The VT isthmus revealed a broad path with inferior entrance and anterolateral exit in the epicardial base of the right ventricle. Thus, a novel ventricular map (VEDUMap) of electrogram (EGM) duration (unpublished data), which considered the duration of the EGM in a color-coded fashion (white = longest to purple = shortest) displayed with auto-color was created **(Figure 1C)**. The region of the prolonged EGM during VT corresponds to the slowest conduction in sinus rhythm. Radiofrequency (50 W at 43°C with an open irrigated catheter) (FlexAbility™ ablation catheter) was started at the white spot highlighted by the VEDUMap with sudden interruption of the tachycardia (green dot in **Figure 1) (Video 1)**.

After a single RF pulse, the VT was no longer inducible up to the fourth extrastimulus. A line of radiofrequency energy was delivered between the two VT isthmus boundaries. LPs were abolished and confirmed by remapping. The patient remained free from arrhythmia at 11 months of follow-up.

The authors report no conflicts of interest for the published content.
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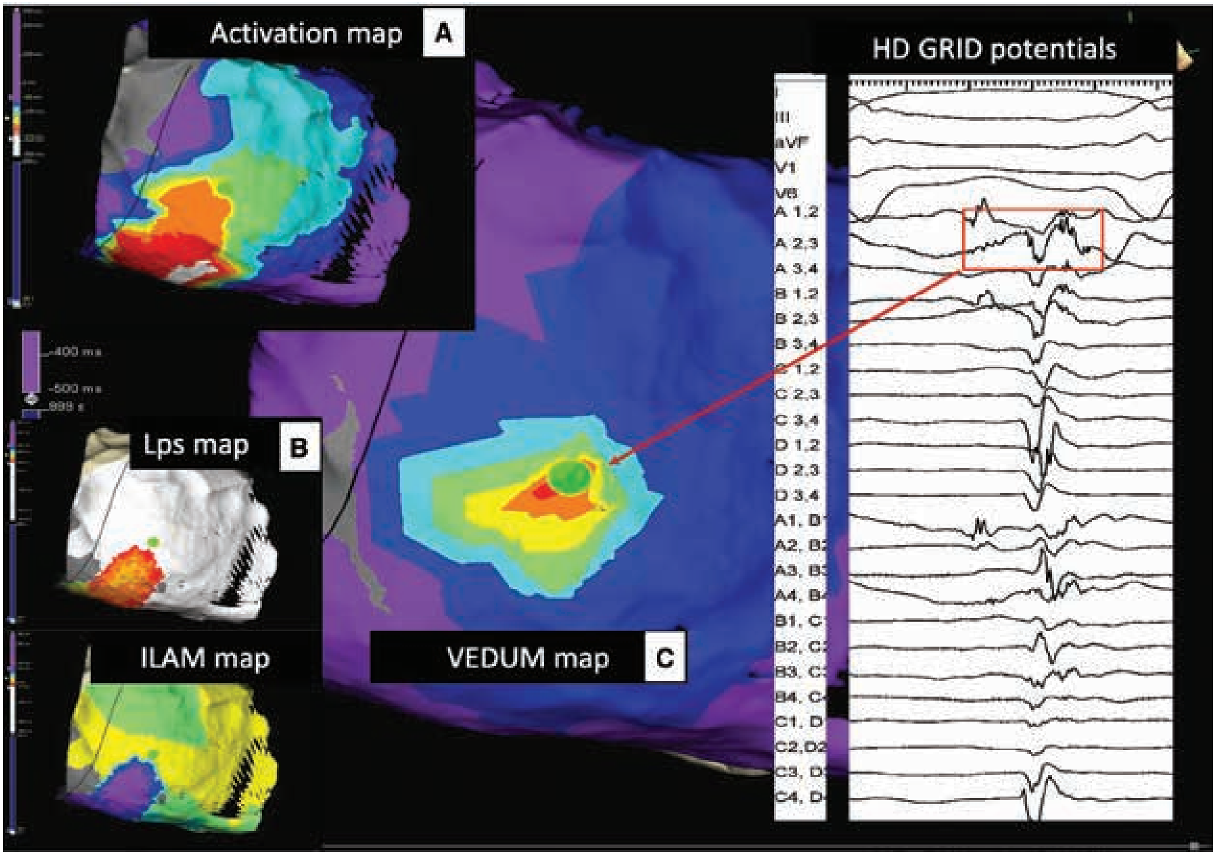

Figure 1: A: Activation map with first deflection detection shows a broad VT isthmus with an entrance on the inferior epicardial wall (white) and exit towards the right ventricular epicardial base. **B:** Sinus rhythm maps (local activation time map) with LPs map and isochronal late activation map. **C:** Ventricular map of EGM duration shows the crucial spot of VT interruption. The EGM recorded by the A2,3 bipoles (white color in the VEDUMap) in the EGM cover more than 60% of the diastolic phase. The green dot indicates the site of radiofrequency interruption.

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LEFT VENTRICLE

Advisor™ HD Grid Use in the Setting of Papillary Muscle Ventricular Tachycardia

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KEYWORDS. *Advisor HD Grid, idiopathic ventricular tachycardia, papillary muscle.*

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A 63-year-old female with a history of nonischemic cardiomyopathy and systolic heart failure presented with frequent premature ventricular complexes and ventricular tachycardia (VT). A 12-lead electrocardiogram (right bundle branch block, II/III discordance, R/S V6 < 1) suggested the anterolateral papillary muscle as the target location. VT matching the documented clinical morphology was easily inducible and sustained at a cycle length of 355 ms.

The Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ was used together with the EnSite™ Precision cardiac mapping system to create an ultra-high density (30,948-point) map while building geometry using the OneMap and Automap tools. A ViewFlex™ Extra ICE Catheter was used to visualize both papillary muscles and confirm accurate papillary geometry. This enabled the map to accurately project points (using the "nearest" algorithm) to the papillary muscles. The high-density grid frequently acquires timing/voltage data that cannot be duplicated by any other catheters; however, these signals of interest can be overridden with higher voltage signals using the "best duplicate" algorithm. Examining duplicates in the area of interest revealed a highly abnormal signal containing 281 ms of the cycle length spanning all of diastole. This point was located in the earliest identified area on the superior aspect of the anterolateral papillary muscle and unipolar signals showed an early QS deflection in that region. A TactiCath™ SE ablation catheter with a DF curve was placed on the area of interest. The signals seen on the high-density grid were not reproducible on the ablation catheter, but the decision was made to deliver a lesion at that location. Using 50 W/40°C with nominal pump parameters, the VT terminated **(Figures 1 and 2)** 0.7 seconds into the first burn and was noninducible after the first burn had been completed. Five additional lesions were delivered in the area of interest; 35 minutes after access was obtained, the procedure was concluded.

Dr. Dandamudi reports advisory board and consulting roles with Abbott; advisory board, steering committee, and consulting roles with Medtronic; and an advisory board role with Biotronik. Mr. Clark is an employee of Abbott. The other authors report no conflicts of interest for the published content.
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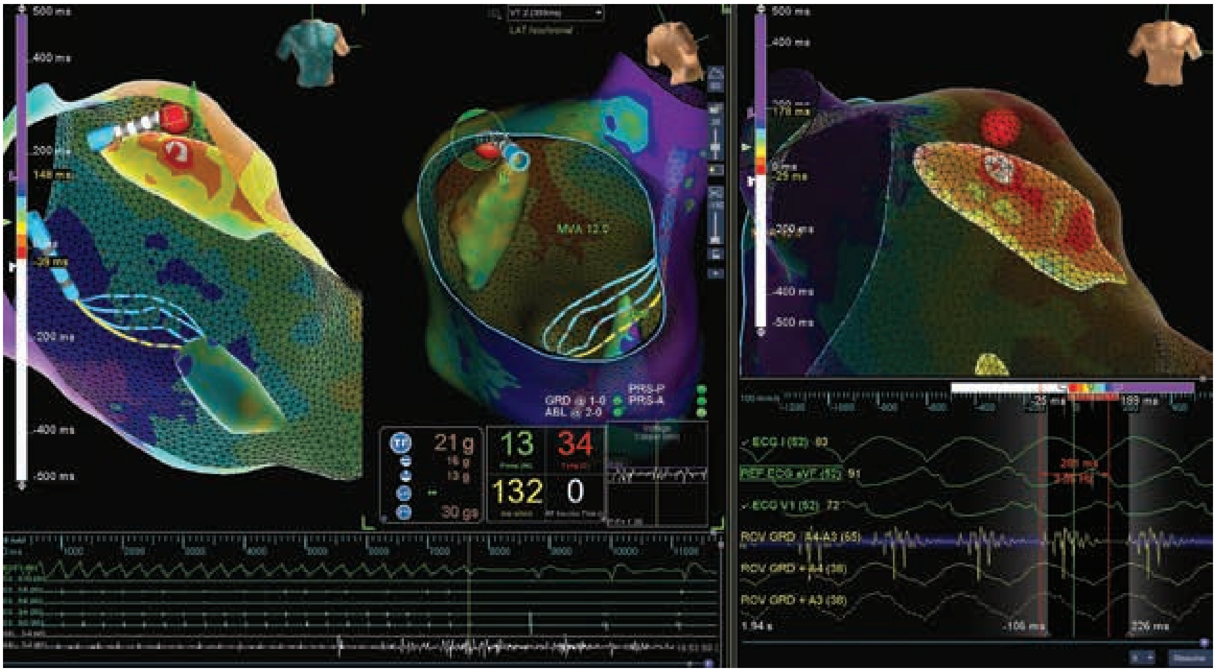

Figure 1: Ablation location, duration (< 1 second), and power (13 W, ramping up to 50 W) parameters when VT was terminated. The image on the right shows the Advisor™ HD Grid signal targeted for ablation. **Video 1** shows map creation, rapid identification of the ablation target, and the termination depicted in **Figure 1**.

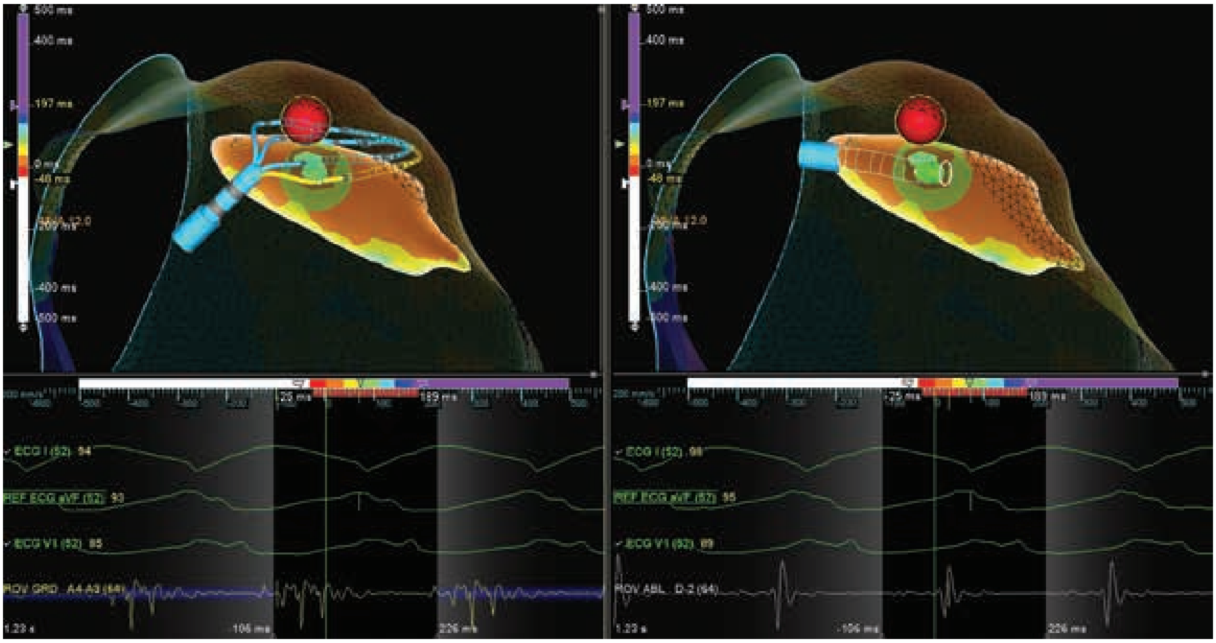

Figure 2: Advisor™ HD Grid signals in comparison with ablation catheter signals at the site of termination prior to ablation.

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LEFT VENTRICLE

Elimination of Incessant Ventricular Tachycardia in Ischemic Cardiomyopathy with High-density Grid Technology

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KEYWORDS. *Extracorporeal membrane oxygenation, high-density grid, ischemic cardiomyopathy, ventricular tachycardia storm.*

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A 76-year-old man with a history of prior anterior-wall myocardial infarction, left ventricular ejection fraction of 25%, and primary-prevention implantable cardioverter-defibrillator placement presented with ventricular tachycardia storm and 17 ICD shocks. Extracorporeal membrane oxygenation (ECMO) was initiated due to incessant ventricular tachycardia (VT) and hemodynamic instability. The VT cycle length was 490 ms, with left bundle branch morphology in lead V1 and negative concordance throughout the precordium. He was brought in for urgent VT ablation and concurrent left ventricular, endocardial, high-density electroanatomic maps were created of the clinical arrhythmia and right ventricular pacing using the EnSite Precision™ cardiac mapping system and a multielectrode grid mapping catheter (Advisor™ HD Grid Mapping Catheter, Sensor Enabled™). A large low-voltage area of 95.7 cm^2 was identified, within which the full diastolic pathway was visualized **(Figure 1 and Video 1)**. The clinical arrhythmia terminated following two seconds of radiofrequency application at a site with early diastolic activation and was not again observed again.

Following subsequent substrate modification guided by targeting of the crowding identified during sinus rhythm isochronal late-activation mapping and fractionation mapping, the patient was noninducible for any ventricular arrhythmia after programmed extrastimulation at two base cycle lengths and up to three extrastimuli. ECMO was decannulated on the second postoperative day and the patient was discharged on the fifth postoperative day. He remained free from recurrent arrhythmia at more than 45 days of follow-up.

The identification of critical locations for reentrant VTs related to large scars can be challenging and labor-intensive. In this case, high-density automated mapping using the Advisor™ HD Grid catheter facilitated rapid identification of the critical site of the clinical VT, while the ablation of areas of automatically identified ILAM crowding and fractionated electrograms rendered the patient noninducible for VT.

Dr. Barbhaiya has received speaking fees/honoraria from Zoll Medical Corporation and served as a consultant for Abbott and Biosense Webster. Dr. Aizer has served as a consultant for Biosense Webster and received fellowship financial support from Abbott, Biotronik, Boston Scientific, and Medtronic. Dr. Chinitz has received speaking fees/honoraria from Abbott, Medtronic, Biotronik, and Biosense Webster and fellowship/research financial support from Medtronic, Biotronik, and Biosense Webster. Ms. Metcalf and Mr. Bonsivutto are employees of Abbott.
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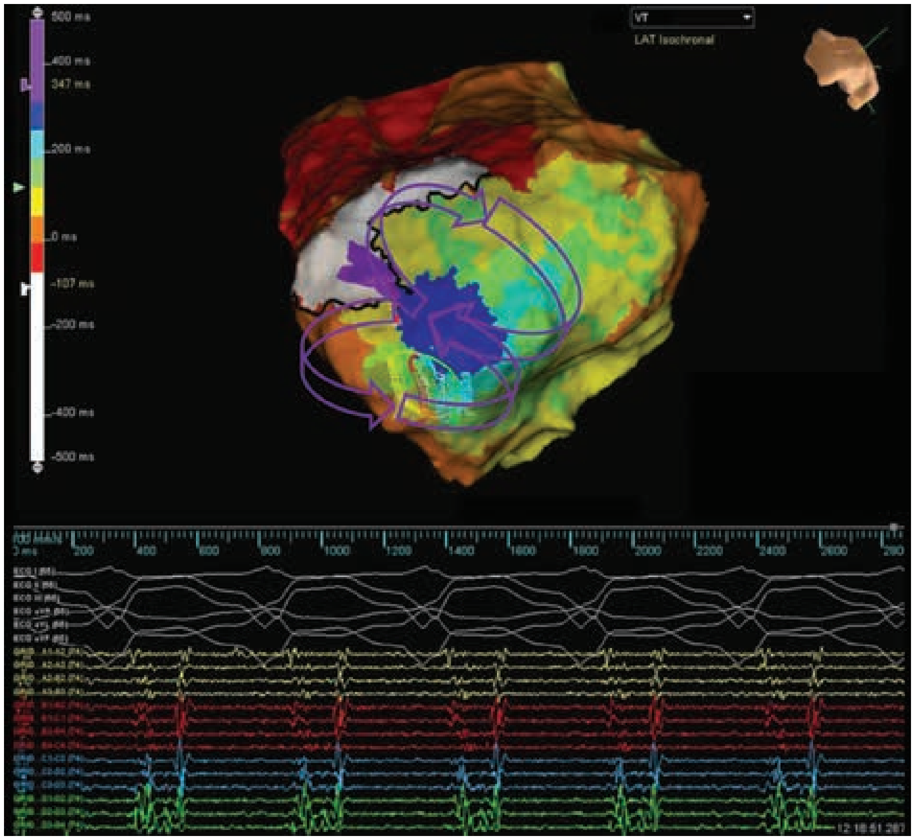

Figure 1: High-density activation map of the clinical VT.

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LEFT VENTRICLE

High-density Grid Mapping Catheter Unveiled a Deceleration Zone in a Large Ventricular Scar

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KEYWORDS. *Deceleration zone, high-density grid, ventricular tachycardia.*

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A 72-year-old male was referred for ventricular tachycardia (VT) ablation due to recurrent episodes of shock despite amiodarone therapy. He had a previous history of coronary artery disease with a cardiac resynchronization therapy defibrillator implanted for secondary prevention, renal insufficiency, and persistent atrial fibrillation. There was no documentation of VT on the 12-lead electrocardiogram. The transthoracic echocardiogram revealed a dilated left ventricle with an estimated ejection fraction of 36%, with an aneurism observed in the inferior wall. During the procedure, no VT was induced. Left ventricle bipolar mapping was performed with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™, while pacing from the right ventricle, and revealed a large area of low voltage (< 0.5 mV) in the inferior wall **(Figure 1A)**. Simultaneous isochronal late activation mapping was automatically performed with the AutoMap Module with Last Deflection-detection Algorithm (Ensite Precision™ Cardiac Mapping System), displayed in eight equally distributed isochrones of activation, and revealed a deceleration zone (> 3 isochrones within a 1-cm radius) inside the low-voltage area **(Figure 1B)**. The visualization of some electrograms with an amplitude as low as 0.03 mV was only possible due to the smaller electrodes with closer interelectrode spacing present in the Advisor™ HD Grid mapping catheter. The sparkle propagation map revealed a possible channel in the low-voltage area **(Video 1)** coincident with the deceleration zone. Radiofrequency was delivered in the deceleration zone and also with the goal of eliminating all local abnormal ventricular activity potentials. After ablation, a new map was created, confirming the absence of deceleration zones and local abnormal ventricular activity potentials. After one year of follow-up, the patient remained free of shocks despite the absence of antiarrhythmic drug therapy.

This case highlights the advantages of using the Advisor™ HD Grid mapping catheter for the identification of deceleration zones in areas of low voltage during ischemic VT ablation.

Dr. Souza reports the receipt of speaker fees from Biosense Webster, Boston Scientific, Medtronic, and St. Jude/Abbott.
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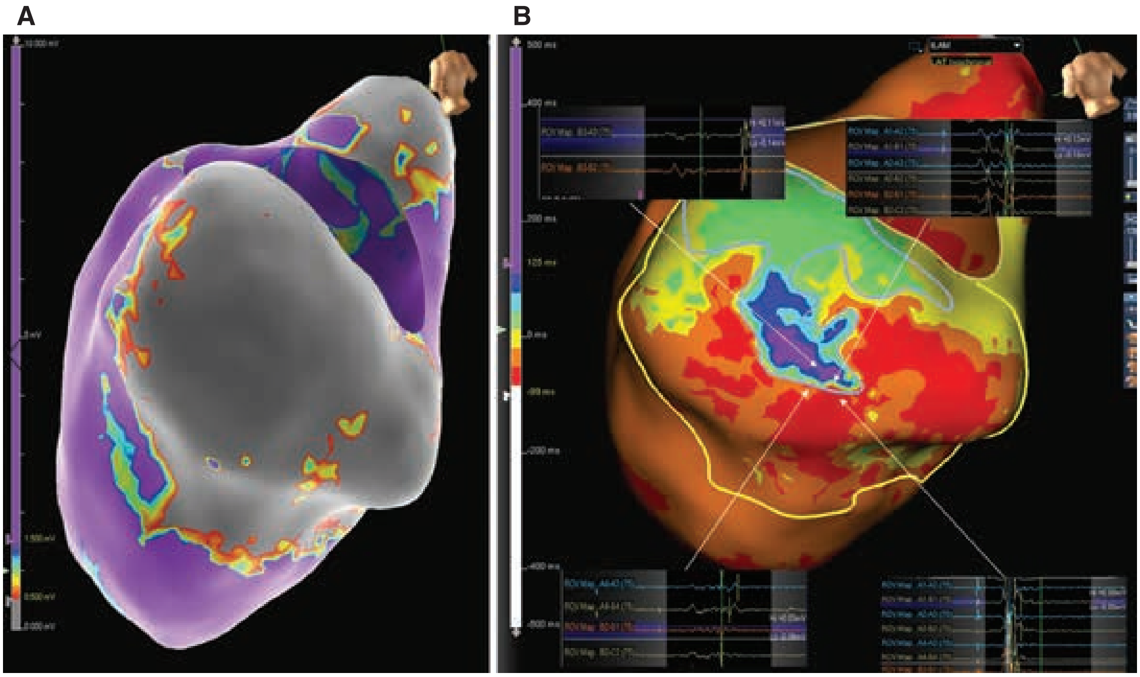

Figure 1: A: An LV bipolar map. The gray coloring indicates areas of probable scar defined as electrogram voltage below 0.5 mV and the purple coloring indicates areas of voltage above 1.5 mV. In between, yellow, green, and blue coloring represent transition areas. **B:** An isochronal late activation map, with eight equally distributed activation isochrones and with a deceleration zone as visualized by the presence of more than 3 isochrones in a 1-cm radius and, demonstrated in the electrograms. The yellow line represents the low-voltage area and the blue line indicates the late potential area.

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LEFT VENTRICLE

High-density Grid and Magnetic Resonance Imaging Working Together

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KEYWORDS. *Ischemic heart disease, ventricular tachycardia, voltage substrate mapping.*

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A 65-year-old man with arterial hypertension, dyslipidemia, and ischemic cardiomyopathy together with three-vessel coronary disease, for which surgical revascularization was performed in 1999, presented to the clinic. In the acute postoperative period, he had experienced a cerebrovascular accident with the sequelae of left hemiplegia, then an episode of cardiorespiratory arrest in June 2019, with an echocardiogram showing dilated ischemic cardiomyopathy with severe ventricular dysfunction, so a single-chamber automatic defibrillator was implanted. He was discharged with bisoprolol and amiodarone as antiarrhythmic treatment. In October 2020, he displayed episodes of sustained ventricular tachycardia (VT) treated with electrical cardioversion. His bisoprolol and amiodarone were exchanged for sotalol. Despite this change, however, the patient had new episodes of VT requiring implantable cardioverter-defibrillators shocks, so ablation was decided. Cardiac magnetic resonance imaging showed extensive areas of fibrosis in the basal and middle areas of the inferoseptal, inferolateral, and anterolateral segments of the left ventricle.

In November 2020, we performed mapping and ablation using a double-access (transseptal and retroaortic) approach. We used the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ for mapping and TactiCath™ SE catheter for ablation. Initially, we performed substrate mapping of the left ventricle, observing two channels matching the fibrosis zone previously revealed by magnetic resonance imaging **(Figure 1)**. Subsequently, a hemodynamically unstable VT was induced with a 700-ms cycle (left bundle branch block, V4 transition, upper right axis). We positioned the Advisor™ HD Grid catheter in the area of interest, observing mid-diastolic signals on the inferobasal channel. We created ablation lines perpendicular to the diastolic channel **(Video 1)**.

In this case, the Advisor™ HD Grid multipolar catheter allowed us to perform substrate mapping with a high density of points and short mapping time. In addition, we were also able to map the VT in a very short time (approximately three minutes) due to poor hemodynamic tolerance, which required electrical cardioversion.

The authors report no conflicts of interest for the published content.
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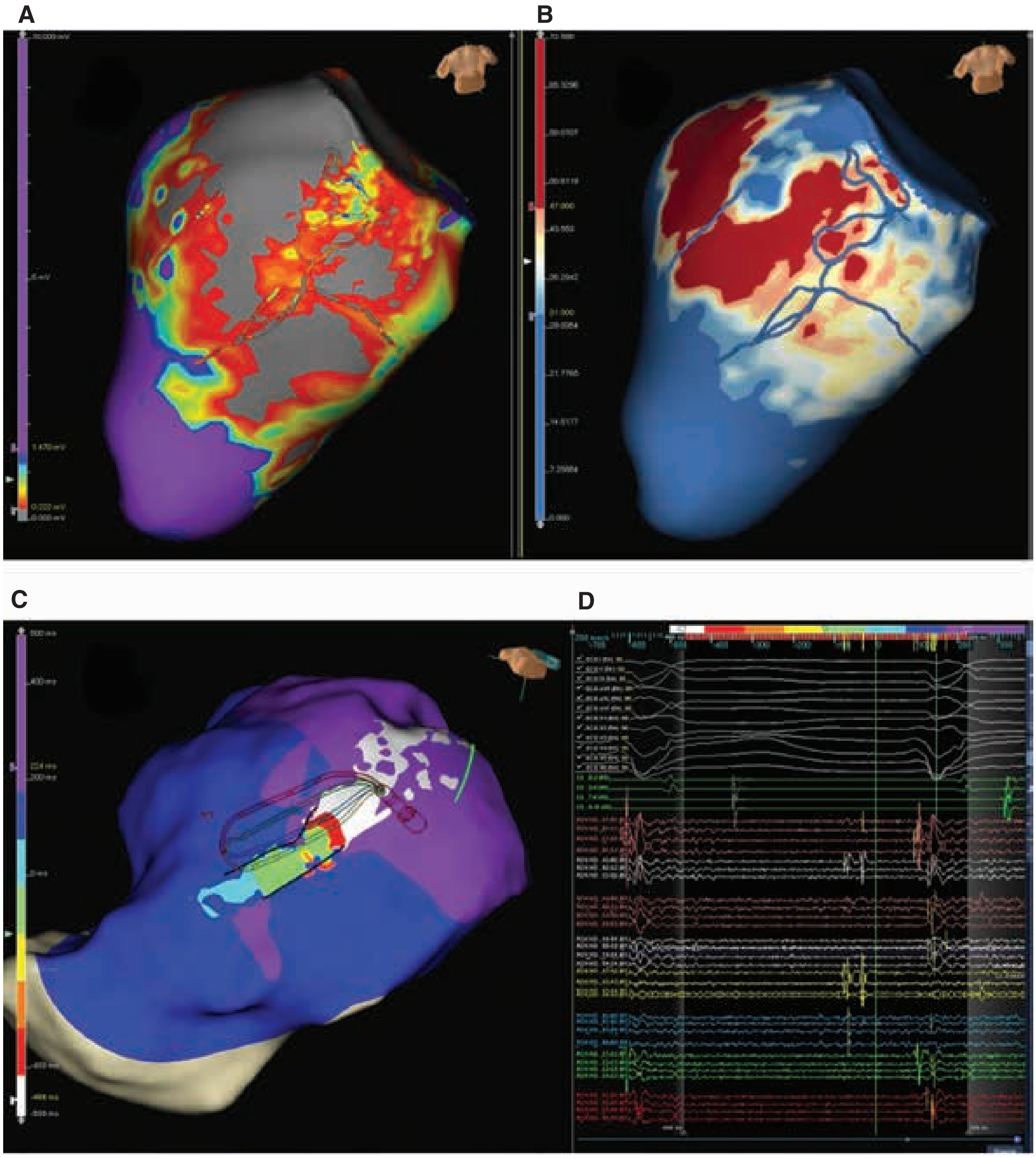

Figure 1: Substrate map in sinus rhythm. **A:** Two low-voltage channels can be seen in the inferobasal area of the left ventricle. **B:** ADAS three-dimensional map (ADAS3D Medical, Barcelona, Spain) and the channels visualized with magnetic resonance imaging. **C:** VT activation map. The VT isthmus is located in the channels seen in **A** and **B**. **D:** Diastolic signals seen in the A spline and the A2–B2 bipole of the HD Grid, located on the isthmus of the VT.

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LEFT VENTRICLE

Decrementing Evoked-potential Propagation Map Defines the Ventricular Tachycardia Isthmus

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KEYWORDS. *Catheter ablation, decrementing evoked potentials, high-density mapping, propagation map, ventricular tachycardia.*

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We present a 65-year-old man with ischemic cardiomyopathy, prior myocardial infarction with mid-left anterior descending coronary artery occlusion, and an implantable cardioverter-defibrillator (ICD) who presented in December 2019 with ventricular tachycardia (VT) storm, receiving several ICD shocks. He was commenced on oral amiodarone; however, in February 2020, he presented with further VT and appropriate shocks. He underwent VT ablation under conscious sedation with antegrade mapping of the left ventricle (LV) using the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ combined with the steerable Agilis™ sheath. The sinus rhythm LV substrate map confirmed extensive septal and apical scar as shown in **Figure 1A**. Within the dense scar region (< 0.5 mV), a low-voltage conduction channel (CC) at the highlighted high-density grid position was identified (white arrow in **Figure 1A**). Sinus rhythm low-amplitude ventricular activities were identified at the anterior border zone (BZ) of the CC; however, as shown in **Figure 1C**, they were buried within the QRS complex.

We routinely performed sensed extras (coupling interval: 400 ms) from the right ventricular apex to identify decrementing evoked potentials (DEEP), as shown in **Figure 1D**. The propagation map of the DEEP potentials is shown in the series of images in **Figure 1E**, highlighting a figure-of-eight activation wavefront starting at the inferior BZ that extended around the scar and entered the CC at the anterior BZ. Ablation at 50 W using the TactiCath™ ablation catheter (lesions shown in **Figure 1B)** targeting the CC entrance site successfully eliminated the CC and homogenized the scar. The postablation propagation map of the DEEP potentials confirmed no further late activation within the scar, with the activation wavefront traversing around the scar from the inferior LV to the anterior LV **(Figure 1F and Video 1)**. Postprocedure, no clinical or nonclinical VT was inducible and the patient has remained free of ICD therapy.

The authors report no conflicts of interest for the published content.
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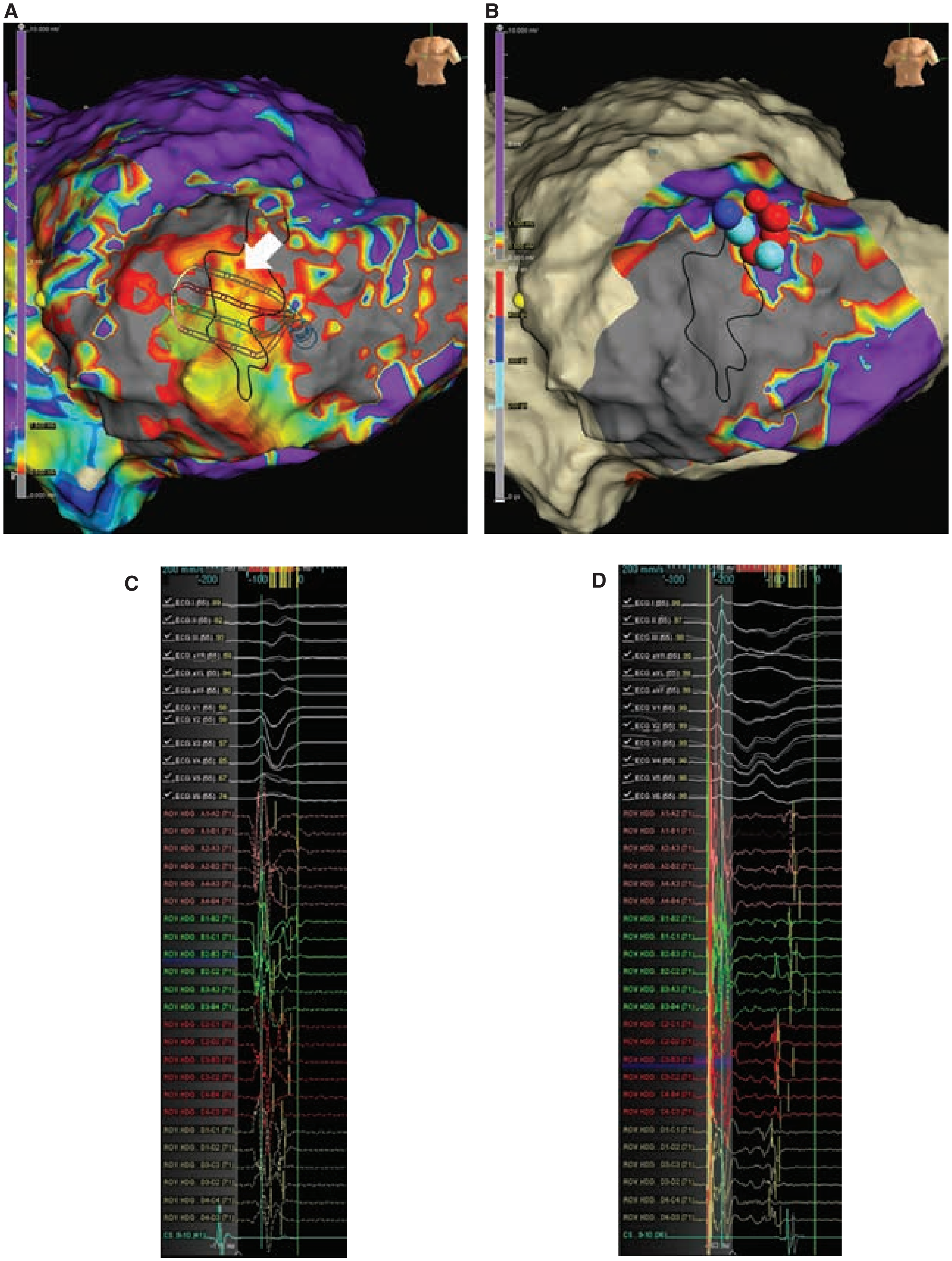

Figure 1: A DEEP propagation map was used to define the VT isthmus. **A:** Substrate map with high-density grid overlaying the VT isthmus. **B:** Substrate map postablation of entrance into the VT isthmus. **C:** Late potentials in sinus rhythm identified within the VT isthmus. **D:** DEEP signals with sensed extras from right ventricular apical pacing.

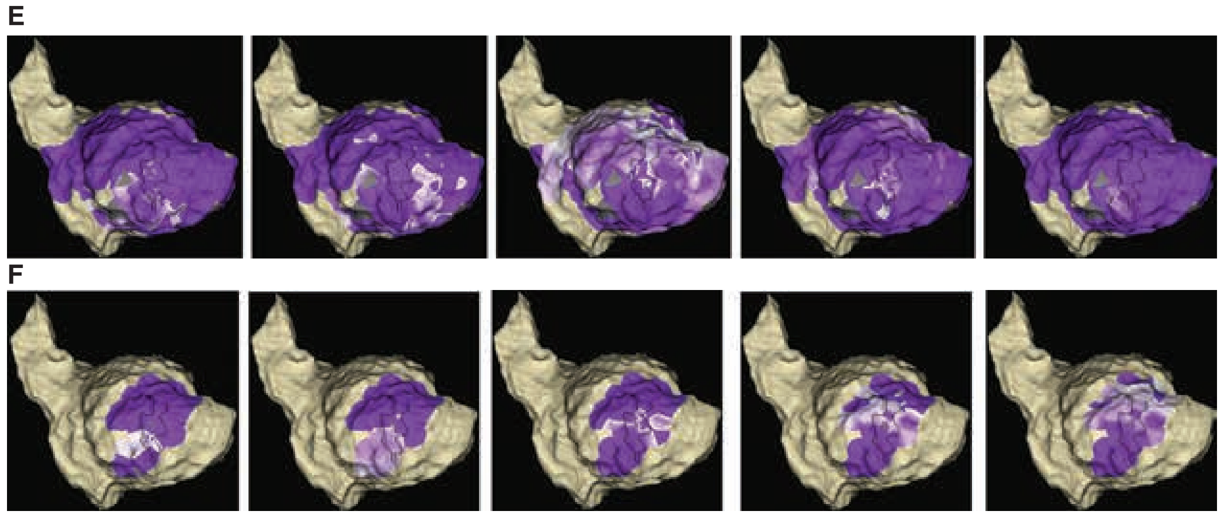

Figure 1: E: Propagation map of DEEP signals preablation. **F:** Propagation map of DEEP signals postablation.

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LEFT VENTRICLE

Using High-density Grid Technology to Map Intramural Left Ventricular Summit Premature Ventricular Complexes with Associated Cardiomyopathy

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KEYWORDS. *Cardiomyopathy, intramural PVC, LV summit.*

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A 69-year-old woman with hyperlipidemia and ocular cicatricial pemphigoid presented with frequent (burden: 47%) symptomatic (ie, palpitations) premature ventricular complexes (PVCs) with an outflow tract morphology and associated cardiomyopathy [left ventricular (LV) ejection fraction: 40%]. She underwent a negative ischemic workup and was started on guidelines-directed medical therapy without improvement in her LV function.

She underwent an initial PVC ablation using activation mapping with an ablation catheter and radiofrequency (RF) energy was delivered from the right ventricular outflow tract (RVOT), LV outflow tract (LVOT), and right–left coronary commissure. Unfortunately, the PVC recurred three months later and her cardiomyopathy continued.

She presented for a redo ablation with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™. Initial activation mapping in the RVOT revealed late timing as was the case in the coronary cusps. Meanwhile, activation mapping with the Advisor™ HD Grid catheter in the LVOT revealed an early fractionated signal just below the left coronary cusp **(Figure 1)**. Activation mapping was then performed in the coronary sinus at the level of the anterior interventricular vein with an ablation catheter. Early far-field timing was also noted in this location.

A coronary angiogram revealed the ablation catheter to be at a safe distance from the left anterior descending coronary artery. Ablation was performed in this region at 20 W with suppression of the PVC achieved after 15 seconds, but it returned after 30 seconds. Attention was then turned to the early signal in the LVOT identified with the Advisor™ HD Grid catheter. Ablation at this site with 35 W eliminated the PVC within five seconds **(Video 1)**.

At five months postablation, the patient remained without any further PVCs and with normalization of her LV function. Guidelines-directed medical therapy is gradually being weaned. This case demonstrates the greater value of high-resolution signal detection with the Advisor™ HD Grid catheter in the case of intramural PVCs relative to traditional ablator-based mapping.

Drs. Alyesh and Sundaram receive consulting fees from Abbott. The other authors report no conflicts of interest for the published content.
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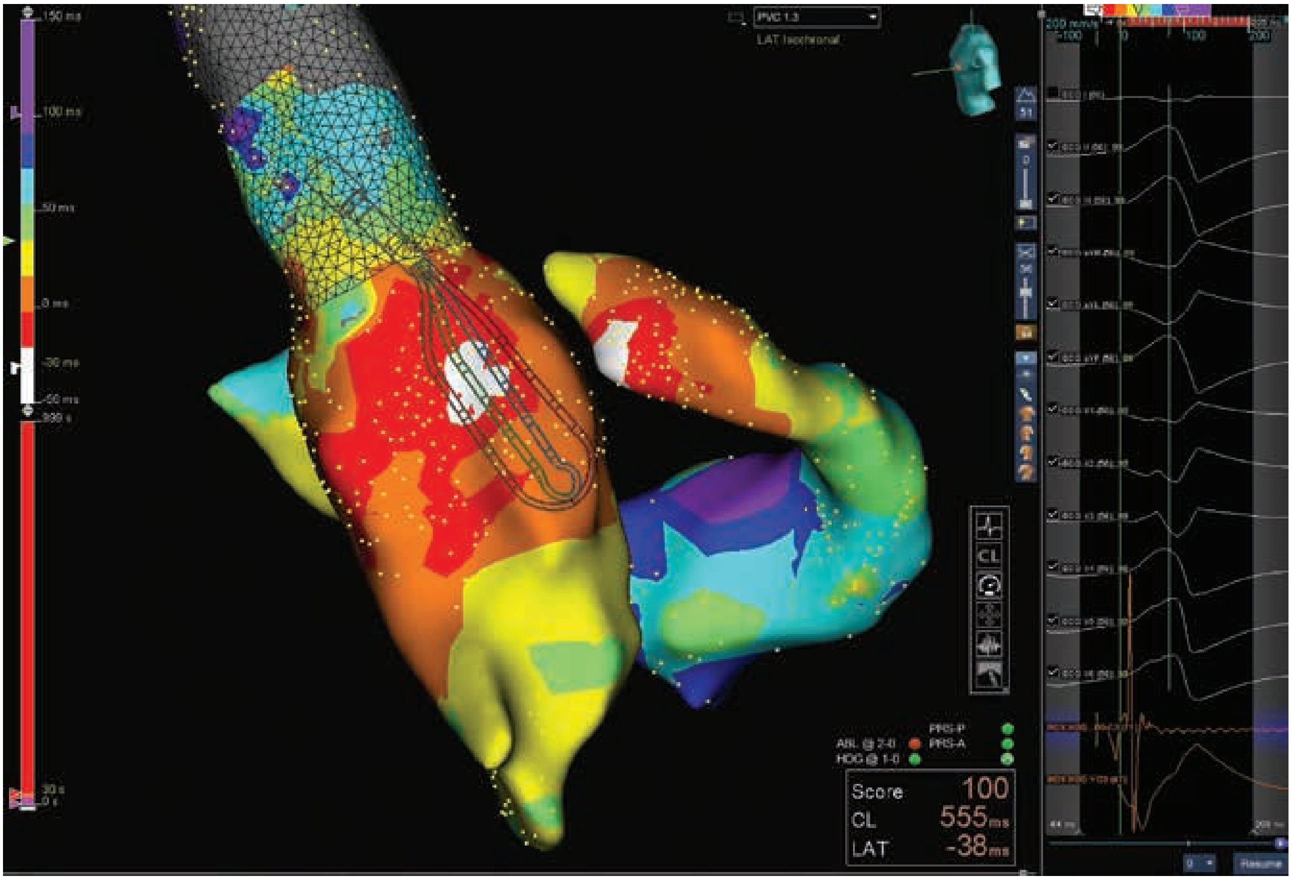

Figure 1: High-density mapping performed with the Advisor™ HD Grid catheter in the LVOT just across the aortic valve identified an early bipolar signal with a corresponding good unipolar signal.

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LEFT VENTRICLE

High-density Grid Technology Aids in the Visualization of Purkinje Potentials in Fascicular Ventricular Tachycardia

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KEYWORDS. *Purkinje potentials, right bundle branch block, ventricular tachycardia.*

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A 71-year-old man with atrial fibrillation (AF), ischemic cardiomyopathy, and ventricular tachycardia (VT) presented having experienced implantable cardioverter-defibrillator (ICD) shocks. He had been previously treated with amiodarone and ICD placement for VT. His last episode of VT was several years prior to admission. About two months before admission, several appropriate shocks were recorded. Despite an increase in amiodarone, in subsequent weeks, he received several additional shocks with syncope. He was hospitalized and an unchanged ejection fraction of 35%, patent bypass grafts, and no new coronary disease were documented. He was then transferred to our institution.

In the electrophysiology laboratory, the baseline rhythm was AF with left bundle branch block (LBBB) and an H–V interval of 59 ms. Voltage mapping of the left ventricle (LV) endocardium with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ revealed only a small area of scar in the anteroseptal LV. During mapping, incessant, repetitive episodes of VT no. 1 (VT1) occurred with an H–V interval of 79 ms **(Figure 1)**. Attempts at entrainment from the right ventricle repeatedly led to termination. Bundle-branch reentry VT was diagnosed and ablation of the right bundle led to the cessation of VT1.

Subsequently, repetitive episodes of a right-bundle, superior-axis morphology VT no. 2 (VT2) were seen. Intracardiac electrograms and a 12-lead electrocardiogram suggested an origin near the left posterior hemifascicle **(Figure 2)**. Entrainment attempts from this area led to termination. The Advisor™ HD Grid catheter was placed in this region **(Figure 3)**, demonstrating a fascicular potential of about 50 ms pre-QRS and retrograde Purkinje potentials. Ablation at this site resulted in termination of the repetitive VT2 salvos **(Video 1)**. The patient remained without further sustained VT at three months of follow-up.

This case suggests the Advisor™ HD Grid catheter is useful in rapidly identifying the presence and direction of conduction of fascicular potentials during the ablation of fascicular VT.

Dr. Saluja has served as a consultant to Abbott and Biosense Webster. Dr. Wan has served on steering committees for Medtronic and Boston Scientific and has received National Institutes of Health funding for research not related to this article. Dr. Biviano has served as a medical advisory board member for Abbott, Boston Scientific, and Biosense Webster. The other authors report no conflicts of interest for the published content.
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Figure 1: The baseline rhythm was AF with LBBB conduction and an H–V interval of 59 ms. VT1, repetitively initiated with catheter manipulation, had an H–V interval of 79 ms, suggestive of bundle-branch reentry VT. Attempts at entrainment led to termination. Ablation of the right bundle was performed with subsequent cessation of the VT. In this figure, the right ventricular catheter is in the His position.

Figure 2: Repetitive episodes of VT were seen. The conducted QRS was a right-bundle type with a prolonged H–V interval after ablation of the right bundle. The ablation catheter is in the region of the left posterior hemifascicle. The potential QRS time was roughly 20 ms both in sinus rhythm and VT (arrows), suggesting the catheter was located at or downstream of a fascicular origin of the VT. In this figure, the right ventricular catheter is in the His position.

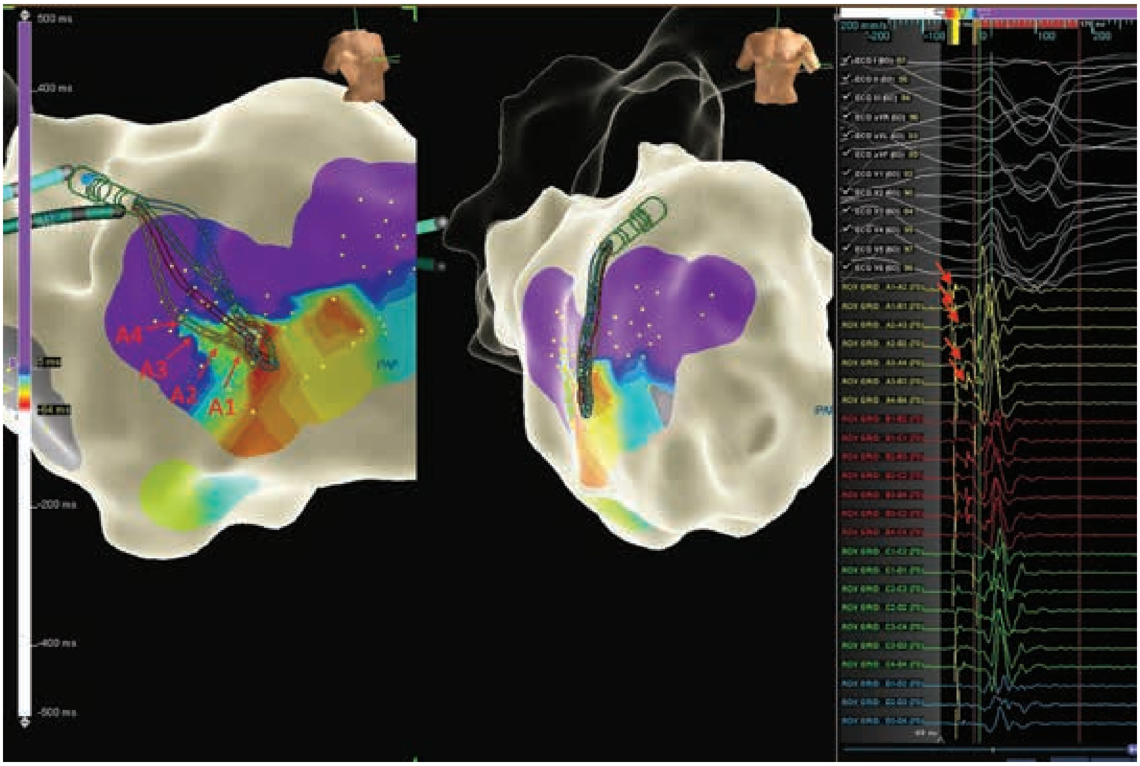

Figure 3: Advisor™ HD Grid signals showed the earliest Purkinje signals were at about 50 ms pre-QRS (A1–A2), with retrograde activation of Purkinje potentials evident (arrowheads).

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LEFT VENTRICLE

Multipolar Mapping for Ventricular Tachycardia Ablation in a Patient with Left Ventricular Assist Device

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Left ventricular (LV) assist devices (LVADs) are a treatment option in patients with advanced heart disease. Ventricular tachycardias (VTs) are common in patients with continuous-flow LVADs and have been associated with increased mortality rates.[1] In this new clinical scenario, ablation has been proposed as a very promising treatment tool.[2] Herein, we report a case of VT ablation in a 67-year-old patient with ischemic cardiomyopathy and severe LV dysfunction who had previously received an LVAD (HeartMate III) implanted as a bridge to heart transplantation. The patient was admitted to the intensive care unit due to multiple VT episodes with a suspected inferolateral and apical origin **(Figure 1)**. VT episodes were resistant to antiarrhythmic drugs and to antitachycardia pacing, so a decision was made to perform VT ablation.

After a single transseptal puncture, a steerable sheath (Agilis®) was placed in the LV and a multipolar mapping catheter (Advisor™ HD Grid Mapping Catheter, Sensor Enabled™) was advanced until the zone of interest was reached. Special attention was needed to avoid contact between the catheter tip and the inflow cannula of the LVAD, which was placed in the apex[3] **(Figure 2)**. The Advisor™ HD Grid catheter is characterized by significant tip flexibility and adaptability to the cavity surface, which allow the operator to conduct very detailed anatomical mapping of the LV and high-definition reconstructions of the area surrounding the inflow cannula that projects into the LV cavity **(Figure 3)**.

Voltage and activation mapping were performed, showing late and highly fractionated potentials all around the cannula, especially in the inferoapical–septal aspect **(Figures 4 and 5)**. Programmed ventricular stimulation induced three different VTs, including two corresponding with clinical ones; unfortunately, all induced VTs were nonsustained and complete activation mapping was not feasible. Nevertheless, multipoint rapid acquisition and high-definition mapping with the Advisor™ HD Grid catheter allowed us to localize areas of putative critical isthmus. These areas, located in the inferior–apical–septal aspect of the inflow cannula border zone, showed very slow conduction and mid-diastolic electrograms during nonsustained VTs **(Figures 6 and 7 and Video 1)**. Ablation was performed with the irrigated TactiCath™ SE catheter, targeting areas of previously annotated late potentials and mid-diastolic electrograms, especially in the surrounding of the inflow cannula. The postablation programmed ventricular stimulation did not induce any VT. Final remapping showed complete abolition of all late potentials **(Figure 8)**.

The authors report no conflicts of interest for the published content.
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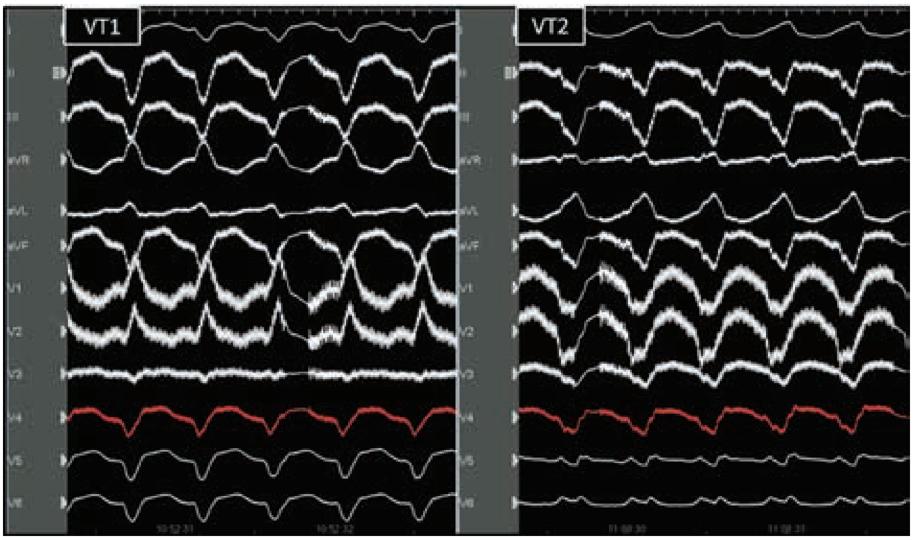

Figure 1: A 12-lead tachycardia electrocardiogram.

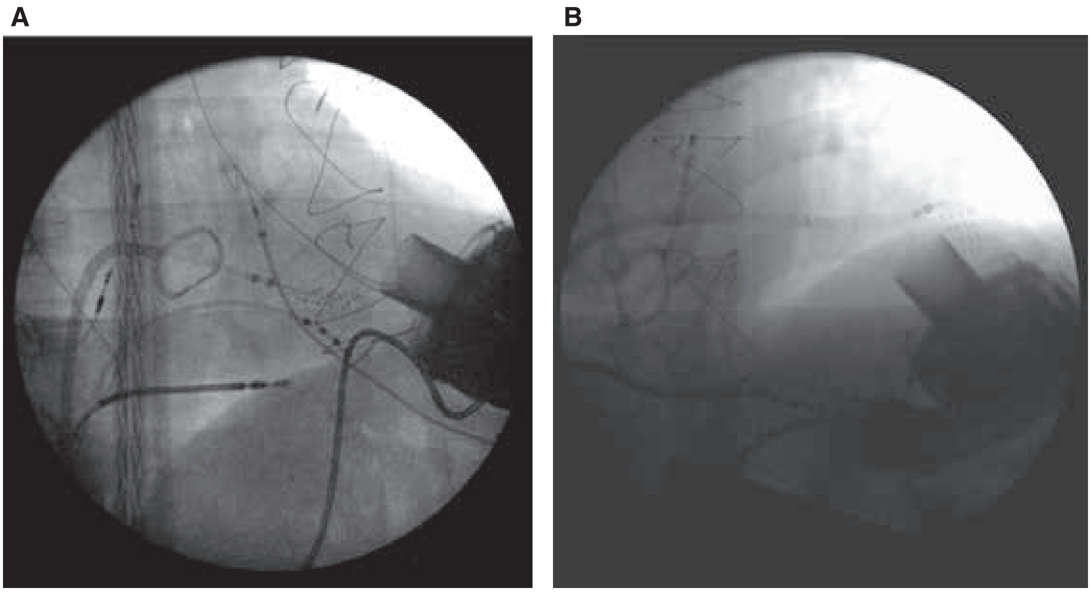

Figure 2: Right anterior oblique fluoroscopy image of two positions of the Advisor™ HD Grid catheter during mapping around the inflow cannula.

Figure 3: Left and right anterior oblique projections of the anatomical reconstruction showing the inflow cannula of the LVAD (red transparency).

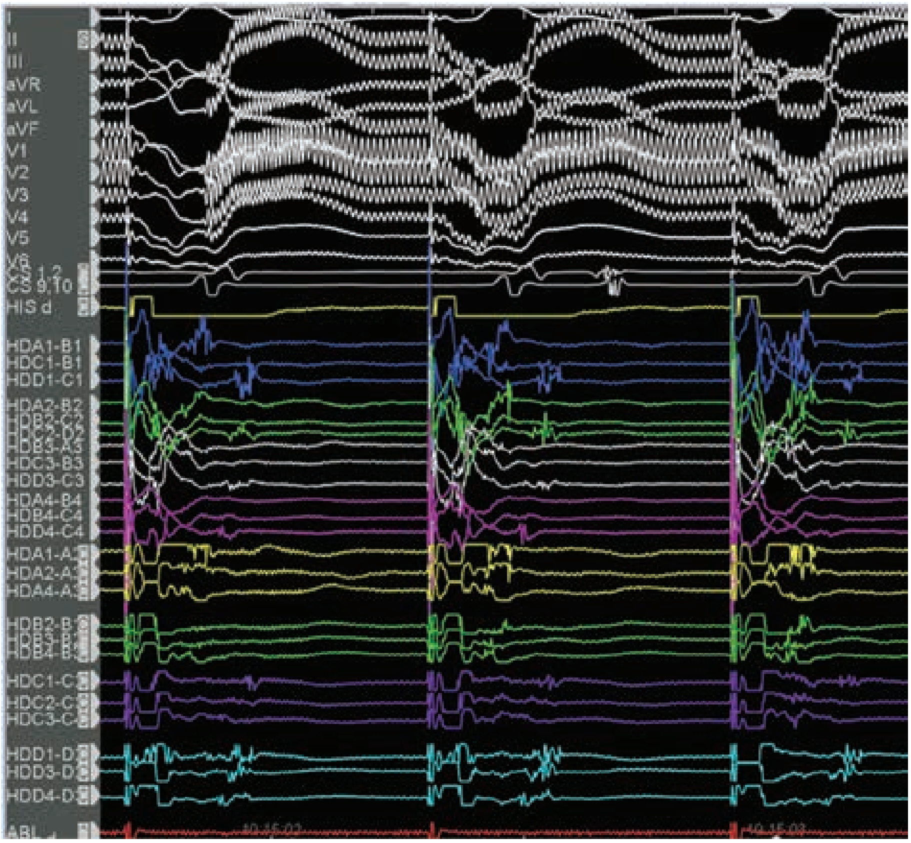

Figure 4: Late and highly fractionated potentials mapped with the Advisor™ HD Grid catheter.

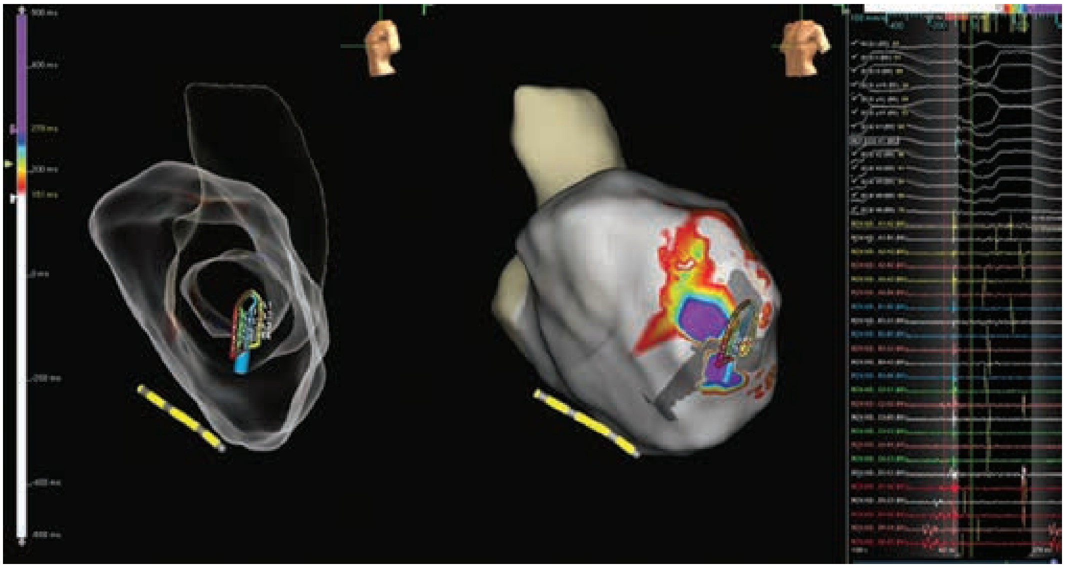

Figure 5: Late-potential activation map showing an area of late activation around the inflow cannula.

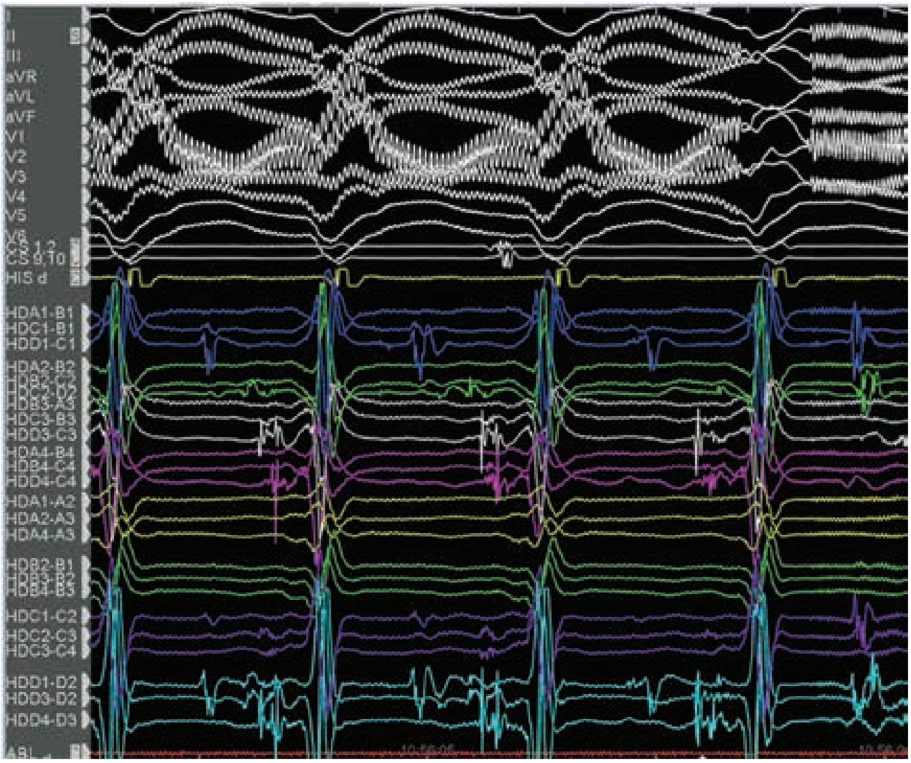

Figure 6: Mid-diastolic electrogram during VT1 mapped with the Advisor™ HD Grid catheter.

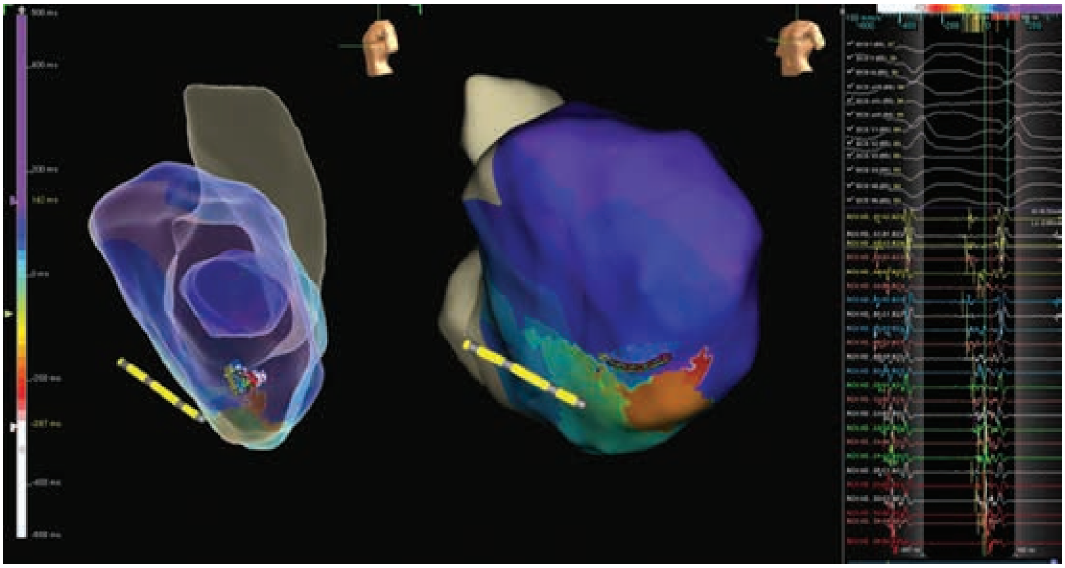

Figure 7: Nonsustained VT1 mapped with the Advisor™ HD Grid catheter and showing mid-diastolic potentials at the slow-conduction zone.

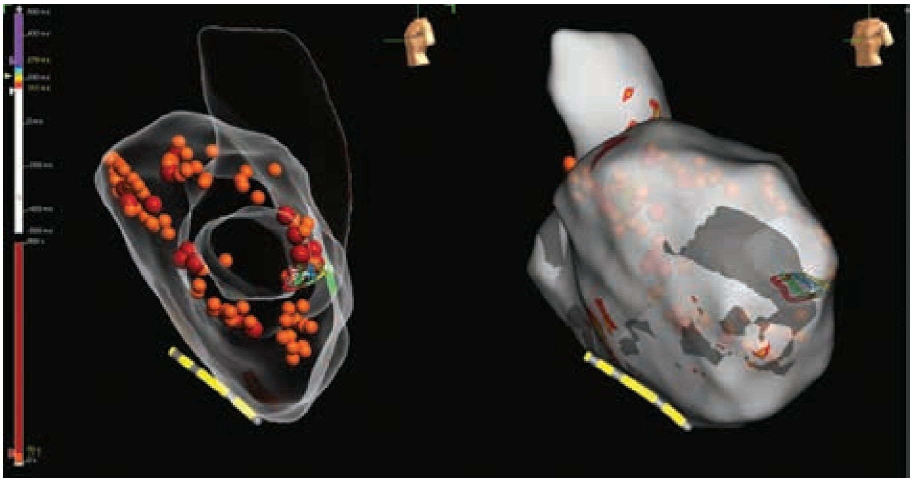

Figure 8: Activation mapping performed after ablation showing complete abolition of the late potentials.

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EXPERT COMMENTARY

Impact on Practice with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™

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This commentary roundtable offers insights from experts on how Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ has impacted their practice, including challenges it has helped to overcome and contexts in which its use has proved particularly valuable.

Toshimasa Okabe, MD
The Ohio State University Wexner Medical Center, Columbus, OH, USA

Dr. Okabe has received honoraria and consulting fees from Medtronic, Biosense Webster, and Abbott.

Roderick Tung, MD
Pritzker School of Medicine, University of Chicago, Chicago, IL, USA

Dr. Tung reports receiving honoraria for speaking from Abbott.

Ashit Patel, MD
Cascade Cardiology LLC, Salem, OR, USA

Dr. Patel reports performing consultative work for Abbott and Spectranetics.

Christopher Woods, MD
Sutter Health, Sacramento, CA, USA

Dr. Woods is an unpaid consultant to Abbott.

1. What past procedural challenges has high-density grid technology enabled you to overcome?

Dr. Okabe: I have found that gaps in the pulmonary vein isolation (PVI) lines can be hard to find using conventional circular mapping catheters, which may result in redundant or unnecessary ablation applications. By carefully moving the Advisor™ HD Grid catheter along the lesion line and over the carina, any gaps can be readily revealed and targeted with focal ablation to close them.

Dr. Patel: The Advisor™ HD Grid mapping catheter has been a welcome addition to my practice and is now the main mapping catheter used in almost all complex cases. For the first time, it provides us with significant feedback concerning the contact force applied to intra-cardiac structures as suggested by the grid perturbation angle. This allows us to visualize and create actual intracavitary structures and to assure appropriate three-dimensional geometry. The catheter itself is quite flexible and atraumatic but, importantly, its design enables better maneuverability near prosthetic valves or chorde. The EP field has not seen this before in a diagnostic catheter or high-density grid mapping catheter. From a recording standpoint, the Advisor™ HD Grid catheter has the ability to create orthogonal signal cross-check recordings, thus eliminating conduction directionality recording issues.

Dr. Tung: The Advisor™ HD Grid technology allows for evenly spaced mapping density in a small region. Contact in the chamber of interest has also been an important variable and this catheter allows for nice apposition with the endocardial or epicardium surface. Meanwhile, the redundancy in catheter bipoles facilitates confirmation that abnormal electrograms are useful and the directionality of the wavefront is an important area of further research.

Dr. Woods: The era of super–high-density mapping is obviously upon us. When I started in the field of cardiac electrophysiology (EP), not that long ago, we considered the achievement of a 200-point map to be a heroic feat and, really, a full day of mapping was required to obtain this kind of result! We did not even consider the concept of high-density mapping during training and, at the time, I had received a small business grant through the National Institutes of Health (NIH) to develop optical mapping technology to fill the niche now occupied by high-density mapping. Then, in the last decade, work across many centers has taught us the value of mapping density and, so, the era of high-density mapping began. Just a few years later, it has become routine to make super–high-density maps; I created an 80,000-point substrate map in less than one hour with the Advisor™ HD Grid Mapping Catheter, Sensor Enabled™ and EnSite Precision™ mapping system—so-called super–high-density mapping—for a ventricular tachycardia at 260 bpm as part of a routine day. While my NIH grant is history, the good news is that the advances in super–high-density mapping are very much present and have become foundational to a new era of EP.

I think the use of the Advisor™ HD Grid catheter in combination with the EnSite Precision™ mapping system has been a major reason for these advances. The Advisor™ HD Grid catheter is a superb catheter. It has top-of-the-class maneuverability and can easily display contact based on deformation and deflection on the electroanatomic map (or through fluoroscopy) to define contact. It is incredibly safe, which allows the operator to develop the confidence to reach everywhere one needs to in the heart safely. The fixed grid creates organized vectors of electrodes, which provide real-time feedback of circuits during mapping. To use super–high-density mapping, one has to adjust to allowing the computer to make the map. EnSite Precision™—and the forthcoming EnsiteX system—do just that with aplomb.

However, we are still EPs and being able to adjudicate signals in real time is critical to analyzing and confirming the map. Thankfully, the Advisor™ HD Grid technology allows for this—and, in fact, was built for this—through its fixed structure of bipoles. I find this characteristic critical to my analysis of isochronal late-activation mapping and critical substrate mapping. Super–high-density mapping makes it challenging to analyze the map in a post-hoc fashion because of the high number of points. So, receiving this real-time feedback is crucial in my view.

2. In which cases/contexts do you find the employment of high-density grid technology to be of greatest benefit in and why?

Dr. Okabe: The use of the Advisor™ HD Grid catheter has been particularly valuable in enabling rapid localization of gaps in prior ablation lines in redo atrial fibrillation cases and in identifying reentrant circuits in the setting of post-PVI atrial tachycardia. Additionally, as compared with when using a point-by-point mapping technique, substrate mapping (bipolar voltage and identification of late potentials) using the Advisor™ HD Grid catheter is efficient and able to pick up electrograms not seen when using an ablation catheter during the ablation of scar ventricular tachycardia.

Dr. Patel: Although the Advisor™ HD Grid catheter can be used in mapping virtually any chamber or structure, I find the most benefit exists when mapping intracavitary structures in terms of attaining more accurate anatomical reconstruction, high-density signals, and the ability to see the directionality of conduction. The Advisor™ HD Grid catheter has made it easier to evaluate moderator bands and papillary muscle in ventricular tachycardia/premature ventricular complex ablation cases. It is also a very resilient catheter when used to map the coronary cusps and subaortic valve structures. Given the design of the catheter, I believe it would be equally effective in epicardial cases.

Dr. Tung: The Advisor™ HD Grid catheter is one of the few catheters that maps that basal portion of the ventricle better than mid- or apical segments. We have found it particularly valuable to map the septum, left-sided conduction system, and periaortic region underneath the aortic valve. It has given us the ability to demonstrate small, localized reentrant mechanisms in patients with anteroseptal nonischemic cardiomyopathy substrates.[1]

Dr. Woods: I think, and data has shown, that super–high-density mapping, such as with the Advisor™ HD Grid catheter, provides the most usable data within substrate, where it has been proven to provide better delineation of circuits with more usable data.[2] Most critically, one not only sees normal tissue better but can also visualize scar better. The entire field of functional scar analysis is possible because of high-density mapping; routinely, we observe signals with the Advisor™ HD Grid catheter that a mapping catheter is fully blind to. I also think that the ability of EnSite Precision™ to employ a dynamic window of interest, dynamic voltage settings, and isochronal late-activation mapping (ILAM) are critical features for this analysis. This has proved useful as demonstrated by Roderick Tung's group at the University of Chicago, for example, as part of ILAM.[3] We have seen the same benefit in delineating critical areas in substrate to maintain atrial flutters (submitted). Furthermore, I have also had tremendous success with managing far more straightforward arrhythmias like Wolff–Parkinson–White. Our group's description of open-window mapping bore this out.[4] I love this technique because, together with revealing the beauty of arrhythmia circuits, it demonstrates the ability of high-density mapping and computation to fully automate ablation targets accurately, which foreshadows where we are going. What an era of EP to be part of!

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