

MINI-FOCUS ISSUE: ELECTROPHYSIOLOGY

ADVANCED

IMAGING VIGNETTE: EDUCATIONAL CORNER

# A Novel Use of Noninvasive Registered Electrocardiographic Imaging Map for Localization of VT and PVC



Daniel Nguyen, MD,<sup>a</sup> Jean Jeudy, MD,<sup>b</sup> Alejandro Jimenez Restrepo, MD,<sup>a</sup> Timm-Michael Dickfeld, MD, PhD<sup>a</sup>

## ABSTRACT

A 33-year-old woman presented with sustained monomorphic ventricular tachycardia (VT). The 12-lead electrocardiogram, 3-dimensional (3D) picture of chest electrodes, and cardiac magnetic resonance were used to create a noninvasive 3D electrocardiographic imaging map to identify the most likely site of VT origin. This map was integrated with a 3D mapping system to aid in VT ablation. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2021;3:591-3) © 2021 Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## CASE DESCRIPTION

A 33-year-old woman with no previous cardiac history presented with sustained monomorphic ventricular tachycardia (VT) associated with syncope. The previous event monitor showed an episode of symptomatic sustained wide complex tachycardia and a premature ventricular contraction (PVC) burden of <3%. A 12-lead electrocardiogram (ECG) showed frequent PVCs and episodes of sustained VT, all with a configuration resembling that of left bundle branch block, such as rightward inferior axis and with precordial transition between V<sub>3</sub> and V<sub>4</sub> (**Figure 1A**). The likely site of origin (SOO) was believed to be the right ventricular outflow tract or the upper anterior right ventricular septum. Routine preprocedural cardiac magnetic resonance (CMR) obtained showed reduced left ventricular function at 48%, without any late gadolinium enhancement suggestive of scar. The likely origin of her cardiomyopathy was believed to be idiopathic. The patient was referred for invasive catheter ablation.

The CMR was imported into the VIVO system software (Catheter Precision, Ledgewood, New Jersey) and segmented to provide a 3-dimensional (3D) endocardial and epicardial anatomic cardiac shell of 1,500 nodes, with each node 2.5 mm in size. A 3D photograph of the patient's chest with 3 fiducial proprietary localization positioning patches and the precise ECG lead positions used to acquire the 12-lead ECG was obtained before the start of the procedure and was merged with the model to determine the spatial relationship between the electrodes and the heart.

Intraprocedurally, VT was induced with ventricular burst pacing at 270 ms on isoproterenol at 10 mg/min. From these data, the system's mathematical algorithm integrated the initial measured 12-lead ECG vector of

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From the <sup>a</sup>Maryland Arrhythmia and Cardiac Imaging Group (MACIG) Cardiac Electrophysiology Section, University of Maryland School of Medicine, Baltimore, Maryland, USA; and the <sup>b</sup>Department of Diagnostic Radiology and Nuclear Medicine, University of Maryland School of Medicine, Baltimore, Maryland, USA. Sarah Moharem-Elgamal, MD, PhD, served as Guest Editor for this paper. The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

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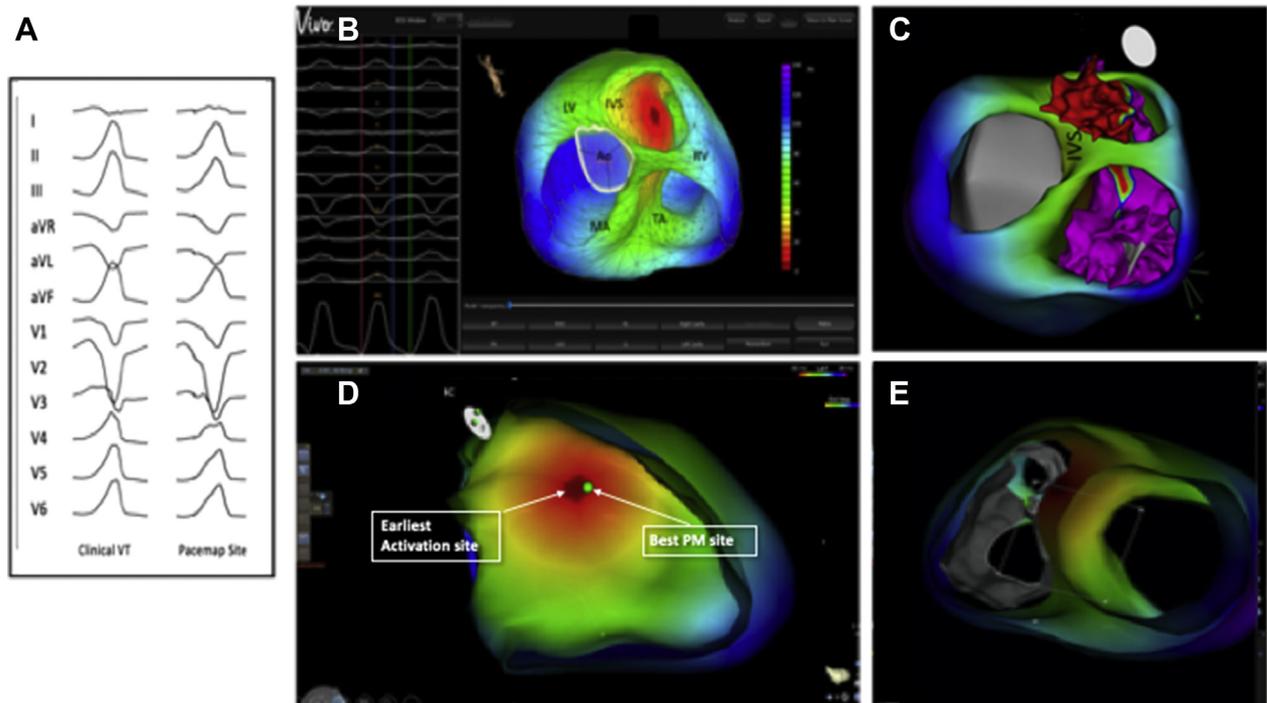
**ABBREVIATIONS  
 AND ACRONYMS**

- CMR** = cardiac magnetic resonance
- EAM** = electroanatomic map
- ECG** = electrocardiogram
- ECGi** = electrocardiographic imaging
- LAT** = local activation time
- PVC** = premature ventricular contraction
- SOO** = site of origin
- VT** = ventricular tachycardia

the VT and the VIVO-generated vector cardiogram to identify the most likely SOO of the VT (1) (Figure 1B). A 3D rendering of the patient’s cardiac chambers was created with superimposed color coding to indicate the area of earliest activation; Calculated local activation times (LATs) were displayed color coded in 5-ms increments (red-to-purple [ms]), with red denoting the earliest site and purple the latest site. The VIVO system independently localized the high right ventricular septum as the likely VT origin (white arrow, Figure 1B).

Simultaneously, a traditional invasive catheter-based 3D mapping system (CARTOSOUND, Biosense Webster, Irvine, California) with intracardiac echocardiography was used to create ultrasound shells of the right and left ventricles and guide the electroanatomic map (EAM) of the right ventricle. Using the VIVO system, an electrocardiographic imaging (ECGi) LAT map was created in a shell form. The file was saved and exported as a VTK file and was placed on a USB drive. The ECGi file was then imported into the CARTO system through the “CARTO Merge Module study” section and by selecting the appropriate study. At that point, registration was performed within the CARTO system on the basis of visual alignment in 3 dimensions (Figure 1C). An activation map was not feasible intraprocedurally because the patient became agitated and required general anesthesia. Using a 3.5-mm irrigated tip, a SmartTouch SF ablation catheter (Biosense Webster), and output of 5 mA at a pulse width of 1 ms, the best pace map match (Figure 1A) (92% PASO match score [Biosense Webster]) localized to the right ventricular septum and co-localized to the predicted VT origin on the registered VIVO map (Figures 1D and 1E). A total of 4 ablation lesion sets were delivered, the total procedure time was 270 min, and no apparent complications were noted.

**FIGURE 1** Co-Registration of Noninvasive Electrocardiographic Imaging With Invasive Electroanatomic Maps



(A) Comparison of clinical ventricular tachycardia (VT) and pace map site; PASO match score (Biosense Webster, Irvine, California) of 92%. (B) VIVO (Catheter Precision, Ledgewood, New Jersey) noninvasive electrocardiographic imaging mapping displaying site of origin in the septal aspect of the right ventricular outflow tract (dark-red node). (C) Registered VIVO electrocardiographic imaging and CARTO (Biosense Webster) electroanatomic map using visual alignment and surface registration. (D) Correlation between earliest activation site from the VIVO system and best pace map (PM) site from the CARTO system. (E) Co-registered merged map of the electroanatomic map and electrocardiographic imaging maps in a short-axis view. The electroanatomic map was colored gray to highlight its registration within the VIVO electrocardiographic imaging shell. Ao = aortic valve; IVS = interventricular septum; LV = left ventricle; MA = mitral annulus; RV = right ventricle; TA = tricuspid annulus.

Including cardiac magnetic resonance segmentation and registration with the EAM invasive map, the entire VIVO process took 75 min, 65 min pre-procedurally and 10 min intraprocedurally. The patient had no VT recurrences during a 6-month follow-up free from antiarrhythmic drugs, and the plan was for reassessment of systolic function in 3 months.

## DISCUSSION

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This case highlights the novel implementation of a noninvasive LAT map for pre-procedural SOO localization of ventricular arrhythmias and integration with a 3D mapping system to facilitate and guide PVC and VT ablations. Earlier studies showed the validity of the VIVO system (1,2) and registration of a currently commercially available 252-lead-based ECGi into an invasive EAM (3). To our knowledge, this represents the first case of co-registration between the VIVO 12-lead ECGi technology with a clinical mapping system. Because the VIVO software is a new technological tool and our center's experience is still limited, the ablation was guided by the standard electrophysiological criteria, which consisted primarily of best pace-map matching in this case. To validate the VIVO-related work flow and performance, the 12-lead ECG data were also used to assess the location accuracy of the VIVO SOO algorithm. The finding that the VIVO determined site co-localizes to the ablation sites determined by standard clinical electrophysiological criteria suggests a possible role of VIVO in target mapping and ablation in future cases. This integrated technology has the potential to define optimal access route and target chamber, decrease intraprocedural mapping time, define areas of high proarrhythmicity in case of a multitude of observed PVCs and VTs, and assist in VT SOO localization in cases of intraprocedural arrhythmia suppression using pre-anesthesia-acquired ECG data.

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**ADDRESS FOR CORRESPONDENCE:** Dr. Timm Dickfeld, Maryland Arrhythmia and Cardiac Imaging Group (MACIG) Cardiac Electrophysiology Section, University of Maryland School of Medicine, Room N3W77, 22 South Greene Street, Baltimore, Maryland 21201, USA. E-mail: [tdickfel@som.umaryland.edu](mailto:tdickfel@som.umaryland.edu).

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**KEY WORDS** ablation, electroanatomic mapping, electrophysiology, imaging, ventricular tachycardia