ESC European Society of Cardiology
Europace (2019) **21**, iii21–iii23
doi:10.1093/europace/euz167

EDITORIAL

Mapping the diastole: ultra-high-density substrate mapping in ventricular tachycardia

Diogo Cavaco[1,2] and Pedro Adragão[1,2]*

[1]Cardiology Department, Hospital de Santa Cruz, Av. Prof. Reinaldo dos Santos, 2790-134 Carnaxide, Lisbon, Portugal; and [2]Cardiology Department, Hospital da Luz, Lisbon, Portugal

Monomorphic ventricular tachycardia is related to an anatomic substrate, usually scar (following myocardial infarction or myocarditis, or in hypertrophic or dilated cardiomyopathy). There is considerable variability in the composition, location, and transmurality of scar and fibrosis in different disorders.

Mapping and ablation of ventricular tachycardia is a complex procedure. Ideally, it would be performed during tachycardia. This would enable accurate identification of the re-entrant circuit and hence a tailored approach to terminate it and prevent recurrence. However, this ablation strategy usually runs into difficulties, including multiple morphologies induced in the electrophysiology lab, haemodynamic instability, or non-inducibility. A different approach involves mapping the substrate and identifying the channels potentially responsible for the arrhythmia.[1]

The development of mapping systems, as well as advances in imaging techniques such as computed tomography, magnetic resonance imaging, and intracardiac echo, have improved anatomical and functional understanding and representation of the substrate.

Several options are available for substrate-based ablation, ranging from a more limited approach, identifying and targeting channels and isthmuses critical to the maintenance of the arrhythmia, to a more general approach that targets all abnormal potentials inside the fibrotic area (scar homogenization).[2,3]

Identifying myocardial scar is a key factor in the success of substrate-guided ablation. With three-dimensional maps from electroanatomical mapping systems, representation of the anatomy can be superimposed on colour-coded electrograms. Areas with reduced electrogram amplitude have shown good correlation with myocardial fibrosis in previous studies.[4] Standard (3.5 mm tip) ablation catheters have several known limitations for substrate mapping, mainly related to the size of the electrodes and interelectrode spacing (3.25 mm). A bipolar electrogram from these catheters represents recording from an underlying tissue diameter of 3.5–5.5 mm. Mapping with conventional catheters is not only inaccurate but also time-consuming. Multielectrode catheters with smaller electrodes and smaller interelectrode spacing enhances mapping resolution in areas of low voltage and scar, enabling detection of areas of preserved myocardial fibres, and identification of diastolic activity (these areas would be classified as dense scar by conventional catheters).[5]

The RHYTHMIA^{TM} mapping system is an ideal tool to accurately map areas of fibrosis in patients with re-entrant ventricular tachycardia. In brief, it consists of a basket catheter (IntellaMap Orion, Boston Scientific) with eight low-noise electrodes on each of eight splines (a total of 64 electrodes with 2.5 mm spacing). The location of each of the 64 electrodes is identified by a combination of a magnetic sensor and impedance sensing. Voltage and activation maps are rapidly and accurately acquired in sinus rhythm or during tachycardia. Individual cardiac beats are acquired automatically. The electrograms are automatically collected and annotated; hence, the map can be created by continuous movement of the catheter in real time, with minimal manual annotation required. The surface geometry of the chamber is continuously constructed by the outermost electrode locations associated with accepted beats. Activation and voltage maps can be constructed quickly with high resolution, due to the automatic nature of annotation.[6]

The use of the IntellaMap basket catheter has been shown to be feasible and safe in patients with ventricular tachycardia. Ultra-high-density maps can be created rapidly, with reliable automatic annotation and consistent recording of abnormal electrograms, thus enabling a detailed characterization of the substrate.[7]

The system can also be used to map infrequent, self-terminating ventricular tachycardias that might have been considered unmappable. A voltage map in sinus rhythm identifies areas of scar and late potentials. With the basket catheter near the region of interest it is possible to create an ultra-fast 'targeted' map after induction of ventricular tachycardia. The same method can be used to map haemodynamically non-tolerated ventricular tachycardias.[8]

In our experience, the system is accurate and reliable and can be used on the endocardium as well as the epicardium. The window of viability can be set at a much lower threshold than usual, fine-tuned for each patient, and voltages as low as 0.01 mV are still above background noise levels—unlike the conventional values of 1.5 mV

The opinions expressed in this article are not necessarily those of the Editors of *Europace* or of the European Society of Cardiology.

* Corresponding author. Tel: +351 967037520; fax: +351 214 241 388. *E-mail address*: padragao@gmail.com

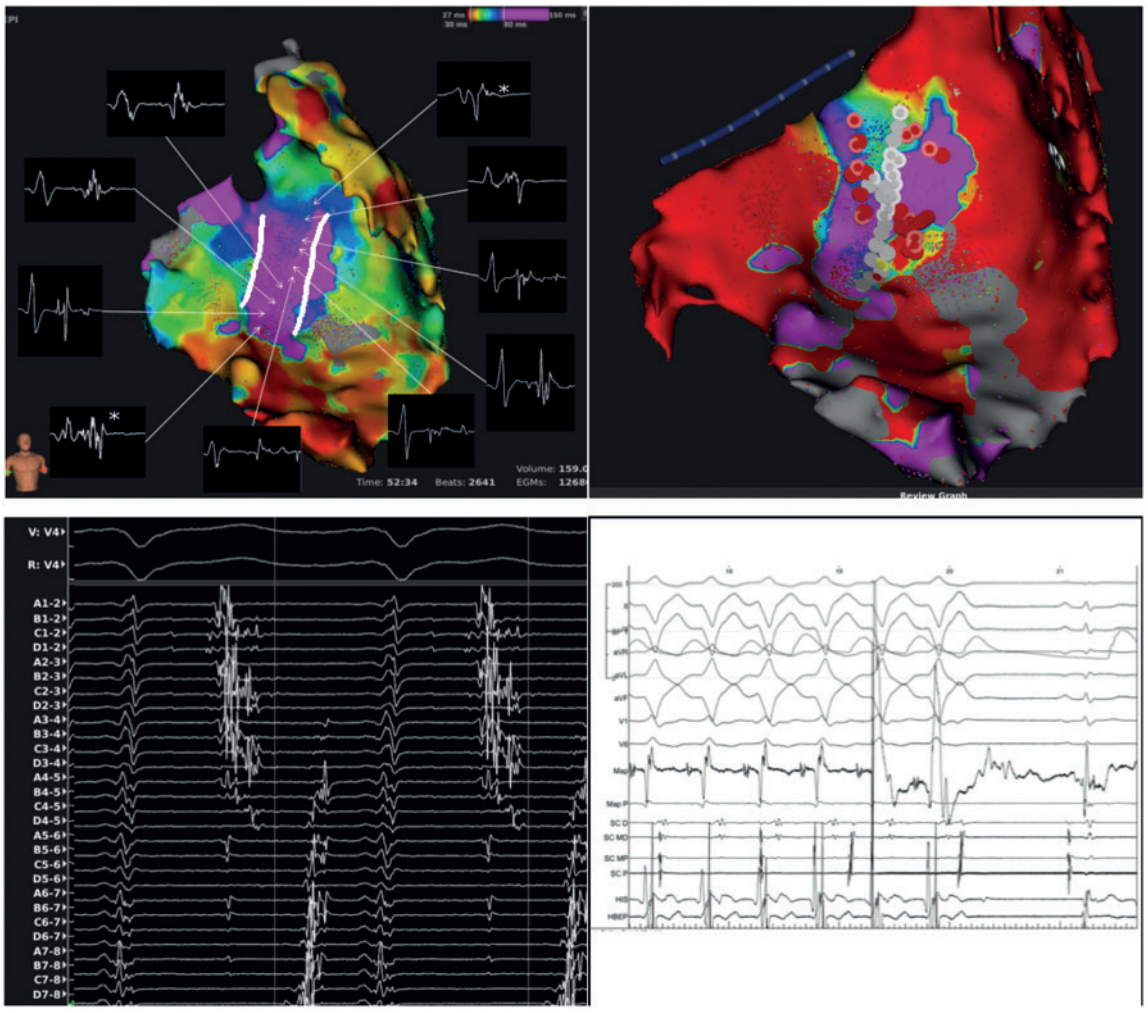

Figure 1 Upper left panel: late potential map. A very wide area is seen in the left lateral wall with late potentials in sinus rhythm, delineating a potential channel. Asterisk (*) marks the points where the distance from the R wave to the late potential is smaller, indicating potential entrance sites to the channel. Upper right panel: the channel is marked with white dots, areas of radiofrequency application with red dots. Lower left panel: electrograms recorded in ventricular tachycardia with the Orion catheter in the late potential area, showing activation covering most of diastole and spanning more than 75% of the tachycardia cycle length. Lower right panel: termination of ventricular tachycardia during radiofrequency application. Adapted from Cavaco et al.[9]

(threshold for viability) and 0.5 mV (dense scar). It is the small interelectrode spacing and the quality of the low-noise signal that enables detection of small potentials within scar tissue, representing viable muscle, which would be missed using conventional electroanatomical mapping. Also available to use with the system is a dedicated catheter (IntellaTip MiFi Open Irrigated, Boston Scientific, MA, USA). This is a 4.5 mm tip irrigated catheter with four mini-electrodes, spaced 2.5 mm apart, which can provide more accurate recording of a focal area and can detect small-amplitude electrograms inside a scar that would otherwise be missed.

The *Figure 1* (adapted from reference 9) shows the use of the system in the epicardial space. The strategy used here was to map in sinus rhythm, in order to identify the channel (in what could be termed 'mapping the diastole'), and then to map during tachycardia, confirming that this area was part of the re-entrant circuit and that a critical isthmus was present at this location. This case illustrates the power of the system for detecting small potentials in sinus rhythm and confirming their participation in the mechanism of the tachycardia.[9]

The Rythmia system enables an accurate diagnosis in most cases of ventricular tachycardia, providing maps that are easy to interpret and a highly detailed anatomy of the substrate, permitting rapid decisions on the best strategy for ablation.

Funding

This paper was published as part of a supplement supported by a grant by Boston Scientific Italy.

Conflict of interest: none declared.

References

1. Emami M, Morton JB, Chan KH, Roberts-Thomson KC. Catheter ablation of post-infarct VT: mechanisms, strategies and outcomes. *Heart Lung Circ* 2019;**28**:76–83.

2. Gökoğlan Y, Mohanty S, Gianni C, Santangeli P, Trivedi C, Güneş MF *et al*. Scar homogenization versus limited-substrate ablation in patients with nonischemic cardiomyopathy and ventricular tachycardia. *J Am Coll Cardiol* 2016;**68**:1990–8.
3. Berruezo A, Fernandez-Armenta J, Andreu D, Penela D, Herczku C, Evertz R *et al*. Scar dechanneling: new method for scar-related left ventricular tachycardia substrate ablation. *Circ Arrhythm Electrophysiol* 2015;**8**:326–36.
4. Callans DJ, Ren JF, Michele J, Marchlinski FE, Dillon SM. Electroanatomic left ventricular mapping in the porcine model of healed anterior myocardial infarction. Correlation with intracardiac echocardiography and pathological analysis. *Circulation* 1999;**100**:1744–50.
5. Tschabrunn CM, Roujol S, Dorman NC, Nezafat R, Josephson ME, Anter E. High-resolution mapping of ventricular scar: comparison between single and multielectrode catheters. *Circ Arrhythmia Electrophysiol* 2016;**9**:e003841.
6. Latcu DG, Bun S-S, Viera F, Delassi T, M El J, A Al A *et al*. Selection of critical isthmus in scar-related atrial tachycardia using a new automated ultrahigh resolution mapping system. *Circ Arrhythm Electrophysiol* 2017;**10**:e004510.
7. Nuhrich JM, Kaiser L, Akbulak RO, Schaffer BN, Eickholt C, Schwarzl M *et al*. Substrate characterization and catheter ablation in patients with scar-related ventricular tachycardia using ultra high-density 3-D mapping. *J Cardiovasc Electrophysiol* 2017;**28**:1058–67.
8. Hooks DA, Yamashita S, Capellino S, Cochet H, Jais P, Sacher F. Ultra-rapid epicardial activation mapping during ventricular tachycardia using continuous sampling from a high-density basket (OrionTM) catheter. *J Cardiovasc Electrophysiol* 2015;**26**:1153–4.
9. Cavaco D, Mesquita J, Carmo P, Adragão P. Epicardial ablation of ventricular tachycardia using a new high-density mapping system. *Rev Port Cardiol* 2019; doi: 10.1016/j.repc.2018.02.013.