Lines, circles, channels, and clouds: looking for the best design for substrate-guided ablation of ventricular tachycardia

Antonio Berruezo* and Juan Fernández-Armenta

Arrhythmia Section, Cardiology Department, Thorax Institute, Hospital Clinic and IDIBAPS (Institut d’Investigació Agustí Pi i Sunyer), C/ Villarroel 170, 08036, Barcelona, Catalonia, Spain

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This editorial refers to ‘Electrical isolation of substrate after myocardial infarction: a novel ablation strategy for unmappable ventricular tachycardias—feasibility and clinical outcome’ by R. R. Tilz et al., on page 1041.

Radiofrequency (RF) catheter ablation of ventricular tachycardia (VT) has become an important part of the therapeutic armamentarium for treating ventricular arrhythmias in patients with structural heart disease. Catheter ablation has proven to control arrhythmic storm and reduce shocks in implantable cardioverter-defibrillator (ICD) recipients with ventricular arrhythmia episodes.2

Novel VT catheter ablation techniques have been developed to overcome the limitations of conventional mapping and ablation. These new techniques aim to characterize and eliminate the arrhythmogenic substrate during stable rhythms. In addition, the advent of three-dimensional non-fluoroscopic systems that allow a detailed electroanatomic reconstruction of the ventricles has facilitated the development of substrate-guided ablation. However, despite improvements in the ablation technology, the rate of recurrence after ablation remains high.3

Based on the surgical experience, Marchlinski et al.4 proposed targeting scar border zone tissue areas with bipolar voltage from 0.5 to 1.5 mV. The best ablation design was considered the creation of ‘linear ablation lines’ transecting the dense scar (<0.5 mV) until reaching the normal myocardium or valve continuity. Pacemapping was used to reduce RF application.4,5

Different markers of VT isthmus have been identified during sinus or paced rhythms and have been proposed as targets for guiding substrate ablation. Conducting channels between unexcitable scar areas identified by pacing or by voltage scanning have been considered an appropriate ablation target and ablation lines to transect them were proposed.6,7

The characteristics of local electrograms beyond bipolar voltage amplitude are critical in the search for potential targets for ablation during sinus rhythm. Various definitions of late, delayed, or isolated potentials have been proposed. Late potential electrograms are very sensitive ablation targets but have low specificity.8,9 The elimination of all local abnormal ventricular activities (LAVAs) has been associated with a better outcome.10 This approach offers a substrate-based ablation procedure endpoint that is more demanding than non-inducibility because it requires the ablation of all substrates, not only the substrate acting as a VT isthmus at the moment of the procedure. Di Biase et al.11 have reported promising results with endo–epicardial homogenization; in this case, all abnormal electrograms were targeted. However, it can be argued that these homogenization techniques are aggressive in terms of the ablation extent required and may be accompanied by an increased risk of procedural complications if performed at less experienced centres.

The ‘scar dechanneling’ technique was developed to minimize the ablation requirements in terms of RF delivery, especially in the epicardium. In this case, the ablation target is the elimination/isolation of the conducting channels by RF delivery at the conducting channel entrances into the scar (the conducting channel electrogram with the shortest delay between the far-field component and the delayed local component).12,13 At UCLA, researchers confirmed with multipole registration that targeting relatively earlier late potentials can eliminate conducting channels and homogenize the scars without extensive ablation.14

In this issue of the Journal, Tilz et al.15 report the methodology and results of a remarkable study that brings light to the field of substrate-guided VT ablation. They used a novel ablation design for VT substrate-guided ablation in post-myocardial infarction patients. The endpoint of the ablation procedure was the electrical isolation of the scar area by means of linear ablations encircling the scar. The authors conclude that electrical isolation of the entire substrate is feasible and appears to be effective in treating infract-related VT. Twelve patients with healed myocardial infarction and ICD shocks were included. Substrate isolation was achieved in half of the patients. After scar encircling, isolation was tested with an octapolar diagnostic catheter. Substrate isolation was defined as the absence of double or late
could help to optimize the ablation procedure.

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plete removal of the substrate is associated with better prognosis.10

provide a clearer endpoint (entrance and exit block) compared

with linear ablation designs. As was reported for LAVA ablation, com-

with a single, extensive, anterior, and dense scar would benefit

with maximum output at multiple sites within the encircled area (exit

The possibility of isolating large scar areas by a circumferential linear

ablation is attractive. It should reduce the extent of ablation compared

with the abolition of all electrograms showing late potentials and

provide a clearer endpoint (entrance and exit block) compared

with linear ablation designs. As was reported for LAVA ablation, com-

plete removal of the substrate is associated with better prognosis.10

This suggests that, either by ablation of all electrograms or by circum-

ferential linear isolation, the verification of the substrate elimination

should be an endpoint for substrate-guided VT ablation. In addition,

the development of an improved multipolar recording technology

that can identify slow conduction entrances into the scar and allow

observing dynamic changes in the conducting channels during ablation
could help to optimize the ablation procedure.

The main limitation of this study is the small sample size, which

limits the strength of assertions on the feasibility and efficacy of

scar encircling in post-myocardial infarction and the capacity to

detect the differences between isolated and non-isolated scars.

The strict inclusion and exclusion criteria, which limited partici-

pation to only 10% of patients with ischaemic VT, raises

doubts about the applicability of the technique to most patients

with myocardial infarction and VT. For instance, 83% of patients

had an anterior infarction when compared with 23–38% in the

multicentre registries of ischaemic VT ablation.3,16 Only patients

with a single, extensive, anterior, and dense scar would benefit

from this approach.

Various substrate ablation targets, RF delivery designs, and proced-

ure endpoints have been proposed for substrate ablation of scar-

related VT in recent years (Table 1). Although they have not been

compared against each other, the new proposals of eliminating all ab-

normal electrograms provide a more reasonable ablation target

when compared with the initial linear ablation models.1,5,10,11

The concept of confirming isolation of the slow conduction paths or con-

ducting channels proposed by Tilz et al. is attractive. However, it

remains to be determined whether it is preferable to perform an

ablation of all abnormal electrograms or to isolate slow conduction

paths within the scar. The best way to achieve this isolation either

Table 1 Proposed strategies for substrate-guided VT ablation

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4 E-IDCs, electrograms with isolated delayed components, separated > 20 ms (Bogun et al.) or > 50 ms (Arenal et al.).
5 Low-voltage electrogram with delayed electrical components (simple or multiple) separated from the higher amplitude component of the local ventricular electrogram by at least 20 ms and recorded after the surface QRS end.
6 Normal electrograms were defined as electrograms with three or fewer sharp and discrete deflections from baseline, amplitude > 1.5 mV, duration < 70 ms (and/or ratio amplitude/duration < 0.046).
7 LAVA, local abnormal ventricular activities: sharp high-frequency ventricular potentials possibly of low amplitude, distinct from the far-field ventricular electrogram, occurring anytime during or after the far-field ventricular electrogram in sinus rhythm and with poor coupling to the rest of the myocardium.
8 CC, conducting channel. The entrance of the CC was defined on the basis of the activation time of the delayed components of the electrogram.

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by linear ablation around the entire scar or by targeting only the conducting channel entrances also remains to be stabilized. 12–14

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References


