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

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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.

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.

Based on the surgical experience, Marchlinski et al. 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.

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.

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. The elimination of all local abnormal ventricular activities (LAVAs) has been associated with a better outcome. 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. 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). At UCLA, researchers confirmed with multipole registration that targeting relatively earlier late potentials can eliminate conducting channels and homogenize the scars without extensive ablation.

In this issue of the Journal, Tilz et al. report the methodology and results of a remarkable study that brings light to the field of substrate-guided VT ablation. They used a new 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
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 participation 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 with myocardial infarction and VT. For instance, 83% of 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. Only patients with a single, extensive, anterior, and dense scar would benefit from this approach.

Various substrate ablation targets, RF delivery designs, and procedure 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 abnormal electrograms or to isolate slow conduction paths from this approach.

<table>
<thead>
<tr>
<th>Substrate ablation target</th>
<th>Procedure endpoint</th>
<th>Extension of RF</th>
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<tbody>
<tr>
<td>Scar border zone</td>
<td>Late potentials area</td>
<td>++</td>
</tr>
<tr>
<td>Non-inducibility</td>
<td>Late potential abolition</td>
<td>+++</td>
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<tr>
<td>Non-inducibility</td>
<td>All abnormal electrograms</td>
<td>+++</td>
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<tr>
<td>Non-inducibility</td>
<td>Elimination of LAVA</td>
<td>+++</td>
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<td>Non-inducibility</td>
<td>CC elimination</td>
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<tr>
<td>Scar isolation</td>
<td>Scar isolation</td>
<td>+++</td>
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**Table 1** Proposed strategies for substrate-guided VT ablation

- Ablation lines: Linear ablation from dense scar to normal myocardium
- Short ablation lines: Short linear ablation parallel to the border zone
- Isolated potential ablation: Point-by-point ablation
- Electrically unexcitable scar mapping: Short lines
- Voltage defined conducting channel: Short lines
- Late potential abolition: Clouds of RF applications
- Scar homogenization: Clouds of RF applications
- LAVA ablation: Point by point ablation
- Scar dechannelling: Point ablation isolation + non-inducibility
- Circumferential scar isolation: Circumferential ablation

**Note:**
- E-IDCs, electrograms with isolated delayed components, separated > 20 ms (Bogun et al.) or > 50 ms (Arenal et al.).
- 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.
- CC: conducting channel. The entrance of the CC was defined on the basis of the activation time of the delayed components of the electrogram.
by linear ablation around the entire scar or by targeting only the conducting channel entrances also remains to be stabilised.\textsuperscript{12–14}

**Conflict of interest:** none declared.

**References**


