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MR Scar Imaging and Intraprocedural Registration Into an Electroanatomic Mapping System in Post-MI Patients

The interesting study by Gupta et al. (1) in a recent issue of *iJACC* assesses the feasibility of post-infarct scar identification by delayed-enhanced cardiac magnetic resonance (DE-CMR) imaging and intraprocedural real-time image registration with an electroanatomic mapping system (EAM) for ventricular tachycardia ablation. Scar area measured by DE-CMR was substantially lower when compared with scar area with EAM with a bipolar cutoff value of <1.5 mV (median 12 vs. 29.1 cm^2), although DE-CMR scar area correlation was better at <1 mV compared with <1.5 mV (R = 0.82 vs. 0.62). No unipolar data were presented. The reason for better correlation requires careful thought in the context of the ability of DE-CMR and EAM (bipolar vs. unipolar) to assess scar. Even though >90% of the low voltage points were within 5 mm of DE-CMR defined scar (1), precise scar delineation is important for ablation, to target substrate that will yield better long-term patient outcomes (i.e., avoidance of healthy tissue and targeting border zones and critical isthmi).

An important potential reason for better correlation at <1 mV might be the directional dependence of bipolar amplitudes that over-estimates scar tissue (2) (i.e., a perpendicular wave front will have less bipolar amplitude than one that is parallel). Because unipolar recordings are not subject to directional dependence, sites with lower bipolar amplitude due to the direction of the wave front would have greater unipolar electrogram amplitudes. Similar to Gupta et al. (1), a prior report demonstrated that, when using a bipolar <1.5-mV cutoff, a mismatch of >20% in infarct surface measurement was observed in 33% (3). However, a <6.5-mV unipolar voltage best correlated with the presence of scar on CMR compared with bipolar <1.5 mV (R = 0.86 vs. 0.82) (3). A DE-CMR and EAM scar mismatch might also occur due to technical challenges in regions where lower EAM mapping density occurs due to poor catheter stability and/or wall contact. However, both unipolar (<5.5 mV or <5.8 mV) and bipolar (<1 mV or 1.3 mV) EAM have been demonstrated to correlate well with DE-CMR scar (4)—which included the scar border assessment (gray zone).

Thus, could the authors provide further insight into the scar area discrepancy observed between DE-CMR and EAM at bipolar <1.5 mV? Do the investigators have data on unipolar EAM in this population? Additionally, is the greater scar area on EAM at <1.5 mV due to the gray zone that was not accounted for on DE-CMR imaging? Does the inability of bipolar electrogram to predict epicardial scar promote the use of DE-CMR information and/or the need to use unipolar mapping more frequently, given that transmural/epicardial scar is observed not infrequently (3) and—as mentioned also in the accompanying editorial (5)—that endocardial bipolar EAM might be less sensitive to scar extending into the midwall and/or subepicardium?

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REPLY

We appreciate the comment of Dr. Obeyesekere about our study (1). His question is interesting and points in an important direction: what is the best voltage mapping technique to accurately assess for post-infarction endocardial scarring? The question goes beyond the purpose of our study, which assessed the feasibility of intraprocedural scar registration from cardiac magnetic resonance (CMR) studies to identify a region of interest. We have not analyzed the unipolar data to answer the question in this set of patients. In a prior study, we reported that bipolar data using a cutoff value of ≤1.0 mV was comparable to unipolar data with a cutoff value of ≤5.8 mV with respect to CMR-defined scar size (2). We agree that it is desirable to have as good a match as possible of the electroanatomic scar with the CMR-derived scar. A bipolar cutoff value of 1.0 mV has been confirmed in a porcine post-infarction model that was validated by histology (3). We have no explanation why in 1 study (4) there was a relatively large mismatch of the electroanatomic mapping–defined scar when a voltage cutoff <1.5 mV was used. However, in that study, it was not reported whether the mismatch was smaller if unipolar data were used, and registration accuracy was not reported. Technical issues including inadequate catheter contact might have played a role as suggested by the authors (4). This would affect both unipolar and bipolar voltage maps. Inclusion of the grey zone is less likely to affect scar size. We used an intensity threshold of 2 standard deviations above the mean signal intensity of remote normal tissue as the criterion for scar by CMR. Therefore, areas defined as the grey zone were included in the registered scar. On the basis of our data, we cannot definitively conclude that unipolar voltage is superior to bipolar voltage for accurately characterizing the CMR-defined scar. Bipolar mapping has the advantage of displaying local electrograms devoid of far-field signals, allowing identification of delayed potentials that could be critical for mapping post-infarction ventricular tachycardia. These

potentials often are missed when only unipolar mapping is performed. However, intramural or epicardial scar components cannot be adequately detected by bipolar mapping but can be identified with unipolar mapping (4). Larger patient series with high-resolution electroanatomic mapping are required to identify optimal cutoff values for voltage mapping and to answer the question of whether unipolar voltage is better than bipolar voltage for defining endocardial scar.

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