Title

Scar voltage threshold determination using ex vivo magnetic resonance imaging integration in a porcine infarct model: Influence of interelectrode distances and three-dimensional spatial effects of scar

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EDITORIAL COMMENTARY

Voltage mapping for ventricular tachycardia ablation: *we can work it out*

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Substrate mapping is an integral part of every structural ventricular tachycardia (VT) procedure. It allows to define the abnormal myocardial substrate and perform ablation without the need of activation mapping, which is time-consuming and often poorly tolerated. The mainstay of substrate mapping is identifying areas of low voltage, commonly defined using fixed standardized thresholds, that is, 1.5 and 8.3 mV, for the endocardial left ventricle. But there are some limitations to this "one-for-all" approach, mainly because voltage amplitude is affected by various factors other than the histological characteristics of the underlying tissue: conduction velocity, anisotropy, catheter orientation, electrode size, and interelectrode spacing are all important determinants of voltage in a given location.[1] The aforementioned cutoff values were statistically derived in mapping studies performed using bipolar mapping catheters with a 3.5- to 4-mm tip electrode and a 1- to 2-mm ring electrode separated by 2-mm interelectrode spacing.[2,3] Moreover, the bipolar cutoff value was validated in patients with coronary artery disease and a dense transmural scar, whereas the unipolar cutoff was used to predict the presence of an epicardial scar in patients with nonischemic cardiomyopathy. Is it appropriate to indiscriminately extend these thresholds to different catheter designs and different substrates? In this issue of **Heart**Rhythm, Tung et al [4] help to answer this question.

Using a porcine model of myocardial infarction and magnetic resonance imaging (MRI)–defined scar image integration, the authors elegantly demonstrated how using a fixed statistically derived normal threshold is not fully sensitive to detect nontransmural scar during bipolar mapping, more so with catheters having different bipolar interelectrode spacings (2, 5, and 8 mm). Indeed, when using a statistically derived threshold to define normal voltage values (ie, those above the 95th percentile of the normal distribution), the bipolar low-voltage areas underestimated the MRI-defined scar. Furthermore, given the positive linear relationship existing between voltage amplitude and bipolar interelectrode distance, these 95% cutoff values were higher with wider interelectrode spacings. As a consequence, a fixed statistically derived bipolar threshold is even less sensitive in detecting a surface scar when mapping with catheters having interelectrode spacings wider than 2 mm. Another important finding was that unipolar mapping is not accurate in predicting the epicardial substrate in the presence of an endocardial scar: using a fixed 95% threshold, the endocardial unipolar low-voltage area overestimated the epicardial scar in most of the cases. By showing that healthy endocardial areas close to a scar had low unipolar voltage despite a normal epicardial substrate, the likely explanation is that unipolar mapping does not discriminate between an adjacent endocardial scar and an across scar. Therefore, a fixed unipolar threshold, applied without regard to the extent of the endocardial substrate, may lead to an overestimation of the scar present beyond the endocardium (either midmyocardial or epicardial).

Taken together, these findings highlight the limitations of a widespread use of the current fixed voltage criteria for scar detection during electroanatomic mapping. As different catheters with various electrode sizes and interelectrode spacings are becoming available, catheter-specific thresholds are needed to improve scar characterization. Moreover, VT ablation is being performed in increasingly different cardiomyopathies with more complex substrates (patchy non-subendocardial scars), where it is essential to associate voltage mapping—ideally using patient-specific thresholds—with an accurate qualitative analysis of electrograms (ie, presence of split, late, and/or fragmented potentials).[5] These are also the substrates in which real-time image integration holds a promising future in the field of substrate-based VT ablation,[6] as once more shown here by the important insights gained with ex vivo MRI integration.

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