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Beyond High-Density Mapping: Is there a Gold Medalist?

Multielectrode Mapping with a Linear and a Grid Catheter Configuration.

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The quest for a 100% success rate in ventricular tachycardia (VT) ablation is driving a large body of research to improve the techniques we use for mapping to decide our ablation targets. Comparing old technologies with newer ones is a fundamental way of moving the field forward. One of the critical issues that newer mapping tools and catheter designs need to solve is to provide the most physiological depiction of the underlying substrate, i.e. to deliver a comprehensive and reproducible electrical picture of the myocardium being mapped at each beat. In that sense, multielectrode mapping (MEM) has been responsible of an important step forward. But not all MEM tools are created equal, and catheter design is of paramount importance when trying to solve one of the main issues that affect our ability to map the myocardium: the directional dependency of the angle of the wave front being mapped with respect to our bipolar electrodes. *In silico* works and preclinical and clinical data has shown us that no matter how closely spaced is your pair of bipoles the directional dependency of the signal being mapped will always be very relevant (1-4), apart from the inherent tissue anisotropy. To tackle this issue -among others- a grid catheter with orthogonal pairs of electrodes was designed.

In this issue of JACC: EP, the group of Tung R et al provide very relevant novel data using the Advisor HD grid (TM) catheter in a series of patients referred for VT ablation. The authors studied a group of 38 consecutive complex patients with average 3.3 induced VT morphologies per patient, due to different aetiologies (20 ischemic patients, 18 non-ischemic) and with most of the patients having undergone a previous failed VT ablation. In approximately 1/3 of patients an activation map of the VT circuit was possible. Interestingly, in a subset of 17 patients, a high density substrate was depicted with the use of 2 completely different multielectrode catheters: Linear duodecapolar catheter -Livewire (TM)- (1mm electrodes, 2mm edge to edge, 20 poles) or a 16-electrode flat grid (Advisor HD grid (TM)) (1mm electrodes, orthogonally spaced, 3mm edge to edge) with 24 pairs of bipolar EGMs. Their approach to mapping and ablation has been reported previously elsewhere (5) and for that targeted ablation to be successful a high-resolution activation and voltage depiction of the endo and epicardial substrate is of critical importance. With each new mapping tool, a comparative study such as the one the authors underwent is much welcome in the EP community to fulfil the ultimate goal of improving the outcome of our patients and to critically apprize its value. Moreover, this is one of the first series of patients being mapped for VT with the HD grid.

Important observations of the study considered as a whole are:

1. The grid is safely and effectively deployed both endo and epicardially allowing for good contact with the tissue and manoeuverability.
2. High-density and high-resolution activation maps during sinus rhythm obtained with the grid help identify the critical components of the circuit in the vast majority of patients.
3. The grid catheter studied well the substrate of non-ischaemic aetiologies that have traditionally been very difficult to map and target with RF.

4. Non inducibility was achieved in 74% of patients with an average total RF time of 27 minutes and many VTs terminated early with RF at the isthmus.
5. At 6 months' follow-up, 74% of patients were still free of any VT and 3 patients died due to non-arrhythmic events.

With regards to the comparison done in 17 patients between a linear catheter and the grid catheter the main findings are:
1. The areas of low voltage (using standard 1.5-0.5mV and not catheter-tailored voltage cut-offs) are significantly smaller for the grid than the linear catheter (average ratio grid vs duodeca of ≈ 0.6 for dense scar and ≈ 0.8 for border zones). Importantly, voltage assessment with the grid was coupled with the HD wave software -that picks up the largest signal of the 2 orthogonal bipoles in each acquisition-. Those results are not unexpected as it is known that larger interelectrode distance will lead to larger peak to peak voltages. But it is relevant to see that a 3mm edge to edge coupled with the orthogonal mapping does not miss surviving tissue when compared to a 2mm edge-to-edge electrode distance.
2. The LAVAs identified with the grid seem to be subjectively more fractionated and with higher frequency components, likely meaning that the theoretical increase in far-field contamination with larger electrode distance does not obscure the detection of LAVAs.
3. The functional propagation of intrinsic activation depicts the same deceleration zones with both catheters in the majority -but not all- patients.
4. During VT, in 2 instances, there was diastolic activity that was detected by the grid but not the linear catheter.

As acknowledged by the authors, some of the limitations of the work include: the fact that the VT burden pre-ablation was not captured; the lack of a quantitative analysis of the differences in terms of fractionation, frequency components, near-field vs far-field analysis of EGMs between the 2 mapping tools analysed; and the fact that there was no imaging used to register the LGE areas and allow for calculation of ROC curves to test the best voltage cut-off value *in vivo* in humans for each catheter.

The authors have demonstrated that the coupling of a grid with orthogonal disposition of electrodes with the software solution of HD wave provides a reliable way of removing at least partially the directional influences of bipolar recordings when depicting the arrhythmogenic substrate in the ventricle. Other groups have shown that the sensitivity and specificity for scar detection does not increase with interelectrode spacing below 2mm (2). Moreover, the orthogonal configuration of bipoles has been shown in preclinical models to depict the VT substrate more accurately than with linear configurations of poles (6-8) and recent work has illustrated its usefulness in human VT cases (9, 10).

This work is a great addition to the translational journey of the grid catheter and highlights the importance of the efficient interrogation of the substrate. The grid strategy, compared to a conventional mapping, can translate into an improved functional map, a better defined voltage map and ultimately lead to better focused RF treatment, at the small cost of maybe not being able to see the signals at the tip of our ablation catheter when choosing our RF spots if we are using a catheter without microelectrodes on it.

In the future, the addition of omnipolar EGMs where the detected bipolar signal is displayed between a set of 3 electrodes in the most clinically relevant manner may add to the field of EP mapping an additional twist. In other words, we may be able to detect the signals that contain the most valuable information: either voltage, frequency, activation direction, speed or timing or a combination of all to include all relevant electrophysiology present in a particular spot.

Until then, studies such as the one presented by Tung R et al in this issue, add value to mapping the substrate in several directions to avoid overestimating the diseased area and focus our treatment. In this study, the grid catheter may be our gold medalist.

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