Multi-size electrodes for (hidden) substrate identification in ischemic cardiomyopathy: validation by integration of whole heart histology

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Topic(s):
Ablation of Ventricular Arrhythmias

Citation:

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Background: Ventricular tachycardias (VT) after myocardial infarction (MI) are related to scars with complex geometry. Scar delineation and VT substrate identification relies on bipolar voltages (BV) and electrogram (EGM) characteristics. Early reperfusion therapy results in small, non-transmural scars which may not be identified using 3.5mm tip ablation catheters.

Purpose: To identify the value of combining EGM information provided by simultaneous mapping using micro- and conventional electrodes in the identification of post-MI (hidden) VT substrate.

Methods: Nine swine with early reperfusion MI were mapped using the QDot catheter which incorporates three micro-electrodes at the distal tip of the standard 3.5mm tip electrode (surface area: 0.167mm², spacing: 1.755mm). Systematic analysis of EGM recorded during sinus rhythm, RV pacing at 500ms, and during a short-coupled RV extra-stimulus (RVE) was performed and noted if one or two component signals were seen. The swine were sacrificed and mapping data was projected onto slices of the entire heart. Transmural biopsies corresponding to mapping points were assessed histologically (Fig. A-D).

Results: A total of 196 biopsies were taken. To identify areas with reduced viable myocardium (VM) (corresponding to areas of histological scar) using the standard electrode, cut-off values of unipolar voltage (UV)<5.44mV (sens. 78%, spec. 78%) and BV<1.27mV (sens. 72%, spec. 84%) were found. Using the micro-electrode a BV<2.84mV (sens. 66%, spec. 86%) was identified. By combining the information from UV and BV mapping (both conventional and micro) the sensitivity to delineate scar was increased to 93% (spec. 66%). 32 biopsies were taken at sites at which RVE was performed. If two component EGMs were present on the conventional EGM, they were always also visible on the micro EGM. On histology, an endocardial VM layer was typically separated by a layer of confluent fibrosis from epicardial VM (Fig. E-H). However, there were sites in which a second component was more clearly visible in the micro but was partially obscured within the decay artefact in the conventional EGM (fig. E,F). These biopsies showed complex fibrotic changes on histology. Moreover, there were also sites in which a second component was only visible in the micro EGM (Fig. G,H). These sites typically showed thin layers of endocardial VM with large overlying epicardial VM.

Conclusion: The combined information provided by multi-size electrode voltage increases the sensitivity with which areas of scar are identified and may allow, in conjunction with RVE, an estimate of non-transmural scar geometry and identification of ablation target sites using one catheter. The higher spatial resolution of the micro-electrode allows for the identification of small near-field components which are either not picked up by the large-tipped electrodes or are obscured by the decay artefact produced in conventional EGM.
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