

Impact of Electrode Size on Electrogram Voltage in Healthy and Diseased Tissue

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Introduction: Atrial fibrillation is the most common cardiac arrhythmia, which can be treated using low voltage (amplitude of intracardiac electrogram $< 0.5\text{mV}$) targeted ablation. This important technique, however, is not robust across procedures due to different catheters being used. Characteristics of the catheter can alter the voltage and lead to changes in identified low voltage areas. This study evaluates the impact electrode size has on the voltage in healthy and diseased tissue.

Methods: Meshes were generated to reproduce a realistic set up of tissue, using the Courtemanche cell model, bath and electrodes. Two high conductivity electrodes with interelectrode spacing of 2mm were placed in contact to the tissue and perpendicular to the planar wavefront. Simulations were performed varying the length of cubic electrodes from 0.2 to 2.2mm. A fibrotic patch, represented by non-conductive mesh elements, was set up as collagen. First, with 50% density of all elements inside an ellipsoid region located on the epicardium and then 10% located transmurally.

Results: An inverse relationship was found between the electrode length and the bipolar peak to peak voltage, with 6.4mV difference between 0.2 and 2.2mm. When including epicardial fibrosis, a voltage decrease of 0.2mV was found in electrodes of length 0.2mm, reducing to 0.8mV for 1.8mm electrodes. With transmural fibrosis, a morphological signal change was seen and a 6mV drop in voltage for small electrodes. In this case, minimal change occurred in the voltage between electrodes of length $> 0.6\text{mm}$. However, a difference of 2mV is seen between small electrodes.

Conclusion: Large electrodes deliver smaller voltages. A fibrotic area on the epicardial side has a small influence on the endocardial voltage, amplified slightly by increasing electrode size. Transmural fibrosis delivers significantly smaller voltages than healthy tissue. Electrode size needs to be accounted for when determining low voltage areas using different catheters.

