Analyzing the Effect of Catheter-Sheath Overlapping Status in Local Impedance Simulations

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Background

In the heart, areas of scar and different levels of fibrotic tissue have been identified as potential driving regions of arrhythmic activity. These areas are typically characterized by magnetic resonance imaging or low voltage maps. Since both the aforementioned modalities entail drawbacks when concluding on the underlying substrate, local impedance (LI) measurements have gained attention recently. Intracavitary LI recordings can provide the information required to locate regions of pathologically altered substrate as changes in conductivity may indicate alterations in myocardial functionality. In this context, identifying the factors contributing to the measured LI is a matter of importance to provide accurate and reliable assessments. However, in clinical practice physicians face artifacts that flaw LI values, such as the overlap between segments of the catheter and the steerable sheath.

Objective

To identify the effect of different overlapping status between a steerable sheath and catheter segments in LI measurements by means of in silico experiments.

Methods

Precise, three-dimensional models [1] of the catheters IntellaNav MiFi™ OI and IntellaNav StablePoint™ (Boston Scientific, Marlborough, MA, USA) were developed.

A steerable sheath was added varying its relative position to the ablation catheter to change the degree of overlap between both elements were embedded into a blood box. Meshes were generated to simulate different combinations of catheter-sheath overlapping status with GMSH 4.4.1. and a simulation environment predestined for impedance studies. Distinct conductivities were assigned to electrodes, insulators, and the surrounding blood. Knowing the injected current between the tip and the proximal ring electrode, the simulation can be defined as a forward problem with a unique solution. Clinical studies and in vitro experiments were performed at the Städtisches Klinikum Karlsruhe to validate the simulation results with real sheath artifact problems.

Results

A simulated trace of LI values while moving the sheath along the catheter is shown in Fig. 1. As it was reported in clinical studies, LI measurements increase significantly when reaching the proximal ring.

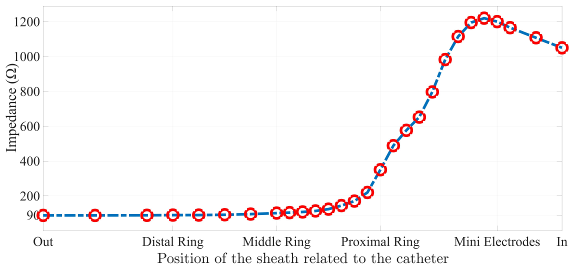

Figure 1: LI values simulated trace as the distal segment of the sheath overlaps the catheter IntellaNav MiFi™ OI.

Discussion

During an electrophysiological study, a steerable sheath is required to help with catheter stability and navigation. However, if the sheath overlaps with one or more of the electrodes, a significant distortion occurs in the LI measurement. Computational models help to understand and solve this artifact, particularly in the boundary regions with marginal but clinically significant LI alterations.

References

[1] S. Pollnow *et al.*, “Mini electrodes on ablation catheters: Valuable addition or redundant information? insights from a computational study,” *Computational and Mathematical Methods in Medicine*, 2017.

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