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Complementary use of contact force and local catheter impedance during RF ablation reduces ablation time in an in vivo swine model

Authors:
K. Garrott¹, A. Sugrue², J. Laughner¹, J. Bush¹, S. Gutbrod¹, M. Sulkin¹, O. Yasin², J. Meyers³, S. Kapa², ¹Boston Scientific - Saint Paul - United States of America, ²Mayo Clinic - Rochester - United States of America, ³Iowa Heart Center - Des Moines - United States of America.

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Catheter-tissue coupling is crucial for effective delivery of radiofrequency (RF) energy during catheter ablation. Force sensing catheters provide a metric of mechanical tissue contact and catheter stability, while local impedance has been shown to provide sensitive information on real-time tissue heating. The complementary use of force and local impedance during RF ablation procedures could provide an advantage over the use of one metric alone.

This study evaluates a prototype ablation catheter that measures both contact force (CF) using inductive sensors and local catheter impedance (LI) using only catheter electrodes. The complementary nature was assessed with discrete lesions in vitro and an intercaval line in vivo.

A force-sensing catheter with LI was evaluated in explanted swine hearts (n=14) in an in vivo swine model (n=9, 50–70kg) using investigational electroanatomical mapping software. In vitro, discrete lesions were created in ventricular tissue at a range of forces (0–40g) controlled externally. RF energy was applied at a range of powers (20W, 30W, and 40W), durations (10s-60s), and catheter orientations (0°, 45°, and 90°). Lesions were stained with TTC and measured. LI drop relative to baseline during RF in the bench studies was used to inform the in vivo study. In a separate subset of animals in vivo, an intercaval line was created in three experimental groups: LI blinded, 20Ω ΔLI, and 30Ω ΔLI. CF was maintained between 15 and 25g in all groups. All ablations were performed with a power of 30W. In the LI blinded group, all lesions were delivered for 30s. In the 20Ω ΔLI group, the investigator ablated until a 20Ω drop or 30 seconds was achieved. Likewise, in the 30Ω ΔLI, the investigator ablated until a 30Ω drop or 30 seconds was achieved.

In vitro, 137 discrete ventricular lesions were created. LI drop during ablation correlated strongly with lesion depth using a monoexponential fit (R=0.84) while force time integral (FTI) did not correlate as strongly (R=0.56). In the intercaval LI blinded group, starting LI ranged from 126–163Ω with a median of 138Ω. LI drops ranged from 13Ω-44Ω, with a median of 26Ω. In the 20Ω ΔLI group, starting LI ranged from 137–211Ω with a median of 161Ω and LI drop ranged from 7Ω-35Ω, with a median of 22Ω. In the 30Ω ΔLI group, starting LI ranged from 130–256Ω with a median of 171Ω and LI drop ranged from 20Ω-52Ω, with a median of 31Ω. Notably, RF time for the LI blinded group was 13±0.1 minutes while RF time in the 20Ω ΔLI group was 6.4±1.9 minutes and 7.5±0.7 minutes in the 30Ω ΔLI group.

A catheter incorporating CF-sensing and LI capabilities provides a powerful tool for RF ablation. Bench studies demonstrate a strong correlation between LI drop and lesion dimensions, which guided the use of LI in vivo. In vivo, the confirmation of stable mechanical contact and viewing of real-time LI drops enabled a significant reduction in RF time while creating a continuous intercaval line.