METHOD FOR TISSUE-TRANSDUCER CONTACT-SENSING OF A HIGH-INTENSITY ULTRASOUND ABLATION CATHETER

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Background: High intensity ultrasound (US) ablation overcomes limitations of shallow radiofrequency lesion depth. The directivity of the US field necessitates a method to confirm contact and orthogonal orientation to tissue.

Objective: To develop a method of tissue contact sensing using pulse-echo imaging from a single catheter-mounted ablative US transducer.

Methods: Side-facing US ablation catheters (13 Fr) were fabricated from 3 x 5 mm (6.5 MHz) and 4 x 5 mm (7 MHz) PZT transducers, mounted with air backing. Catheters were pulsed and reflections were amplified, background subtracted and processed using a Hilbert transformation to generate a “contact value” (CV; blue curve amplitude, Figure). CVs were validated in ex vivo chicken breast and perfused swine myocardium models under direct observation while manually positioning the catheter transducer with respect to tissue in 3 conditions (non-contact, intermittent “bouncing”, and stable contact), after which US ablation (60 sec, 30 W) was applied. Ex vivo CV values were used to determine contact in in vivo swine US ablations of the interventricular septum. Gross pathologic lesions dimensions were quantified after TTC staining.

Results: In both ex-vivo models, CVs were significantly higher with both intermittent and stable contact conditions than non-contact (p < 0.001, Figure), but there was no statistically significant difference between intermittent and stable contact. A CV of > 15 (arb. unit) discriminated between non-contact and intermittent/stable contact with 100% sensitivity, and applications (depth 14.2 \pm 1.5 mm, volume 4,326 \pm 2,330 mm³). Using this CV threshold in in-vivo studies, we noted lesion formation in 97% of US applications, but there was no significant correlation between CV value and lesion depth (10.8 \pm 4.2 mm) or volume (1,770 \pm 1,286 mm³; R² < 0.1 and p > 0.05 for both).

Conclusion: Tissue contact sensing with a therapeutic US catheter using pulse-echo signal processing is feasible without the need for a separate, dedicated imaging transducer. Further refinement of this method is necessary in differentiating stable versus intermittent tissue contact.

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FIBROSIS AND SLOW CONDUCTION PERSIST AFTER RECOVERY OF PREMATURE ATRIAL CONTRACTION INDUCED ATRIAL MYOPATHY IN A SWINE MODEL

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Background: Population studies demonstrate an association between frequent premature atrial complexes (PACs) and left atrial (LA) myopathy; however, causality is unproven.

Objective: To explore the impact of beat-to-beat irregularities in atrial ectopics on the development of atrial myopathy and regression in a swine model.

Methods: Thirty swine were exposed to pacing from the lateral LA for 16 weeks in 4 groups: 1) 50% paced PACs (PAC, n=10); 2) regular pacing at 130 beats/min (Reg, n=5); 3) 50% PACs followed by 6 weeks of PAC cessation (Rec-PAC, n=5); and 4) control group in sinus rhythm (CTRL, n=10). Detailed EP study and echocardiography were performed at baseline and prior to sacrifice; LA fibrosis was quantified histologically.

Results: After 16 weeks, PAC group had a greater degree of LA dilatation (Δ from baseline; 5.9 \pm 1.2cm² vs. Reg 2.5 \pm 0.7cm² vs. CTRL 0.9 \pm 0.3cm²; p<0.001), slower LA conduction velocity (CV) (1.1 \pm 0.2m/s vs. Reg 1.4 \pm 0.1m/s vs. CTRL 1.5 \pm 0.2m/s; p<0.001), no change in atrial effective refractory period (ERP) (Δ from baseline; -5 \pm 6ms vs. Reg -8 \pm 15ms vs. CTRL -3 \pm 25ms; p=0.17), and increased induced atrial fibration duration (Δ from baseline; 131[IQR:30, 192]secs vs. Reg 9[8, 30]secs vs. CTRL -3[6, 3]secs; p=0.001) compared to Reg and CTRL groups. After PAC cessation, Rec-PAC group had improvement in LA size (p=0.02), but no change in CV (p=0.62). Percent fibrosis was higher in PAC group than Reg and CTRL and remained elevated in Rec-PAC group (Figure).

Conclusion: In a swine model, frequent PACs led to an LA myopathy characterized by slow conduction and fibrosis without change in ERP, suggesting a process distinct from tachy-pacing induced atrial remodeling. Slow conduction and fibrosis persist even after cessation of PACs, suggesting that early intervention may be important for preventing ectopy induced atrial remodeling.