Palpation of Intra-cardiac Blood Flow, Pressure, Contact Force and Motor Reaction Time of Subjects Using a Novel Haptic Feedback System

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Background: SMART AF showed that consistent contact during ablation improves pulmonary vein (PV) isolation but use of contact force (CF) displays led to a 2.5% risk of tamponade and required procedural, ablation, fluoroscopy times of 3.7 +/- 1.4 h, 2.0 +/- 1 h and 41.5 +/- 26 min. When the HRS Consensus Document definition is employed efficacy was 66%. CF displays require recruitment of saturated visual attentional resources. The benefits of sense of touch over visual feedback are well established but catheters do not enable palpation of physical events. We tested a novel haptic system (HS) and proprietary sensorized catheter by comparing tactile motor to visual motor reaction times (RT) and evaluated if doctors could use touch to distinguish physiologic signals from different sites.

Methods: We hypothesized that tactile motor RT of doctors palpating haptic feedback due to catheter tissue contact would be less than visual motor RT of historical controls pressing a space bar after noting the disappearance of a continuously visible 500 ms stimulus. Published, digitized waveforms of left atrial appendage (LA) and PV ultrasonic blood flow velocity, atrial pressure and CF during PV ablation (signals) were input into the HS and used to generate palpable sensations in a haptic handle. Doctors holding the haptic handle were asked if they could discern signals from different anatomic sites.

Results: Mean tactile motor RT for two subjects measured 10 times = 185 ms (SD = 32) which was statistically significantly less than visual motor RT for historical controls; n = 93; mean = 321.8 ms (SD = 38.6); $p < 0.0001$ (unpaired t-test) at 95% confidence level. 14 of 14 physicians differentiated haptic feedback from LA and PV, right from left atrial pressure, time of contact with and puncture of the septum, and changes in CF amplitude due to cardiorespiratory cycles. 11 of 14 preferred to control the gain of haptic effect.

Conclusion: The HS provides operators with an intuitive means to distinguish cardiac signals from key anatomic sites and react to the palpation of catheter tissue contact faster than to simple on off visual feedback. The HS may improve procedural success and reduce complications and operative times.