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A self-adaptive approach to antitachycardia pacing - a head to head comparison using advanced computational modeling

D. Swenson[1], J. Blauer[1], R. Taepke[1], E. Kwan[2], E. Ghafoori[2], M. Barton[1], J. Tate[3], J. Coles[1], R. MacLeod[3], P. Degroot[3], R. Ranjan[2]

[1]Medtronic, Minneapolis, United States of America; [2]University of Utah, Div of Cardiovascular Medicine, Salt Lake City, United States of America; [3]University of Utah, Salt Lake City, United States of America

Background: Antitachycardia pacing (ATP) for monomorphic VT (MVT) reduces painful defibrillation shocks. Most ICD-treated ventricular arrhythmias are MVT, suggesting an opportunity for improved ATP to decrease shocks. We report on a new algorithm (Yee, Circ AE 2017) that uses electrophysiologic (EP) first-principles to design ATP sequences in real-time. Heart-rate history is used to design the first ATP sequence, and failed ATP post-pacing interval is used to design later sequences.
Purpose: The purpose of this modeling study was to understand how this new ATP algorithm would perform in a head-to-head comparison with traditional burst ATP. Modeling allows direct comparison of the two algorithms in identical, realistic, patient-derived cardiac arrythmias.
Methods: Patient-specific late gadolinium enhanced MRI and EP data were used to build an adjudicated cohort of realistic numerical heart models with varied EP, infarct, border zone. Publicly available EP modeling software CARPentry was used to calculate sustained reentrant VT initiated with the programmed electrical stimulation used to induce VT clinically. The VTs were physician-adjudicated to validate models. Burst ATP was 3 sequences of 8 pulses at 88% of VT cycle length, each decremented by 10ms. The new ATP was limited to 3 automatically designed sequences.
Results: Three hundred unique VT scenarios were generated from 6 human hearts with multiple VT circuits, 5 electrophysiologic states, and 10 pacing locations. Burst ATP terminated 168/300 VTs (56%) and accelerated 2.7%. The new ATP terminated 234/300 VTs (78%) with the same acceleration. The two dominant ATP failure mechanisms were identified as 1) insufficient prematurity to close the excitable gap, and 2) failure to reach the critical isthmus of the VT circuit. For these mechanisms, the new ATP algorithm reduce failures from 64 to 28 (44% reduction) without increasing acceleration.
Conclusion: The new automated ATP algorithm successfully adapted ATP sequences for VT episodes that burst ATP failed to terminate. The new ATP was successful even with complex scar geometries and electrophysiology heterogeneity as seen in the real world.