Difference in right and left ventricular response during cardiac resynchronization therapy (CRT): insights from canine-specific simulations

Erik Willemen, Marc Strik, John Walmsley, Tammo Delhaas, Frits Prinzen, Joost Lumens

Maastricht University, The Netherlands

Introduction: In cardiac resynchronization therapy (CRT), timing of stimulation affects left (LV) and right ventricular (RV) pump function. Factors influencing the optimal timing of stimulation for LV and RV function are incompletely understood.
Methods: Biventricular (BiV) pacing was performed in dogs with atrioventricular block (N=6) using atrial (A), RV apex and LV epicardial pacing. The acute response to 100 randomized combinations of A-LV/A-RV intervals was tested. For each setting, LV and RV pump function was quantified by the maximum rate of pressure rise (LV and RV dP/dtmax). LV and RV electrical activation times (AT) were measured using epicardial contact mapping and septal AT using plunge electrodes and a multielectrode catheter. LV, RV and septal AT data from 2 dogs were used to create canine-specific simulations using the CircAdapt model. In addition to LV and RV dP/dtmax, the simulations gave insight in the pacing-induced changes of global systemic response measured by stroke volume (ΔSV).
Results: The distribution of change in LV dP/dtmax over the A-LV/A-RV diagram differed strongly from that observed for RV dP/dtmax (Fig. A for example). BiV pacing with slight LV pre-excitation led to the largest increase in LV dP/dtmax (4/6 dogs). LV-only pacing led to higher LV dP/dtmax than RV-only pacing. In contrast, RV dP/dtmax was highest with simultaneous BiV pacing and/or RV pre-excitation (6/6 dogs). LV-only pacing led to lower RV dP/dtmax than RV only pacing. Canine-specific simulations (Fig. B for example) showed a good agreement with the measured LV dP/dtmax but less agreement with RV dP/dtmax. Similar to LV dP/dtmax, the largest SV increase occurred with LV pre-excitation.
Conclusions: Acute hemodynamic response to CRT at different pacing delays is different for the LV than fot the RV. Canine-specific simulations show that optimal systemic response follows measured optimal LV dP/dtmax, suggesting that LV dP/dtmax should be prioritized over RV dP/dtmax when optimizing CRT.