The Role of Cardiac Anatomy in Multipolar Lead Design Optimisation for Cardiac Resynchronization Therapy

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Multipolar pacing, where several electrodes can be stimulated in the same lead, may improve acute response to Cardiac Resynchronization Therapy (CRT). However, the optimal electrode distribution along the lead may vary between patients and change during reverse remodeling of the heart. Testing different configurations in the patient is unfeasible due to the high number of possible permutations and the time available to optimise the device.

We aim to use a virtual cardiac cohort to determine the optimal lead designs in dyssynchronous heart failure (HF) patients and how they change when the heart reverse remodels (RR).

We created a virtual cardiac cohort of 24 HF and 20 RR patients with CT-based anatomy. RR hearts were approximated by asymptomatic patients. We simulated biventricular pacing, using lead designs with 8 possible electrode positions. We activated up to 4 electrodes at a time. Each lead design was placed at 5 potential vein locations. We used RV apex pacing as a baseline. Response was measured by the time between the 10% and 90% of the ventricles being activated (AT1090). Optimal response was defined as the maximum reduction of AT1090 when pacing at some point in the LV free wall with respect to the baseline.

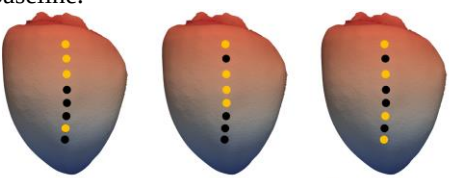

Fig 1. The optimal lead designs for the HF cohort. In yellow, the electrodes of that lead design; in black all the potential electrode locations for that vein position.

With 3 multipolar lead designs we could achieve the optimal response in the HF population, needing 4 if we added the RR cohort. The optimal designs were the ones where the most distal electrodes were activated together with a mix of distal with proximal electrodes. Choosing the global optimal lead design over the personalised optimum caused a maximum decrease of the response of 10.24%.

We established a working testable hypothesis for the design of new quadripolar pacemakers. Although a global optimal design can be design computationally, there is room for personalisation specially after there is remodelling in the heart.