The predictive role of left ventricular cathode topography relative to CMR-determined latest mechanical activation and scar segments on response to cardiac resynchronisation therapy

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Background: Cardiac resynchronisation therapy (CRT) is still burdened by considerable rates of non-response. Herein left ventricular cathode (LVC) positioning has the greatest room for optimisation. Nonetheless, a purely CMR-based approach exploring LVC topography relative to both mechanical delay and tissue viability is yet to be investigated.

Purpose: To retrospectively analyse the effect on reverse remodelling of CMR-determined LVC topography relative to latest mechanical activation (LMA) and scar segments in a CRT population.

Methods: This is a retrospective single-centre analysis of 104 CRT-D/P consecutive patients with CMR performed within 6 months before implantation. Electrical delay (Q-LV time) was mapped on all suitable veins with LV lead positioning and cathode programming set in the region of latest electrical activation. Through CART-Tech® software analysis of CMR images, 36-segment 3D anatomical models of radial strain and scar were superimposed on their corresponding fluoroscopy images (Figure 1). Patients were then stratified based on LVC concordance (within), semi-concordance (adjacent) or non-concordance (at least one segment away) with LMA and scar segments (defined as segments with >50% scar transmurality). Follow-up echocardiography was performed at least 6 months after implantation and the degree of reverse remodelling expressed as percentage reduction in end-systolic volume (ESV).

Results: Of the 104 patients, 36 were excluded due to suboptimal CMR quality (8), switch to conduction system pacing (5), loss to follow-up (18) or death within 6 months of implantation (5), leaving a total of 68 (63 CRT-D and 5 CRT-P). LVC concordance with LMA was associated with a statistically significant improvement in reverse remodelling (Figure 2, A), while the contrary occurred with regards to scar (Figure 2, B). A greater impact of distance from scar compared to LMA proximity was observed, thus a combined analysis of LVC topography relative to both was developed accordingly. Patients were stratified into 4 categories of LVC optimality: optimal (LVC-LMA concordance + LVC-scar non-concordance), semi-optimal (LVC-LMA semi-concordance + LVC-scar non-concordance), suboptimal (LVC-LMA non-concordance + LVC-scar non-concordance), and unfavourable (LVC-scar semi-concordance or concordance regardless of LVC-LMA). The unfavourable group had higher rates of atrial fibrillation, non-LBBB QRS morphology and higher scar burden, while no significant differences were observed in the other 3 groups. This classification appears to predict the degree of reverse remodelling, ESV reduction being more pronounced the more optimal the group (Figure 2, C).

Conclusions: CMR-determined LVC topography relative to LMA and scar segments predicts left ventricular reverse remodelling in Q-LV-guided CRT implants. Optimisation of CRT response may thus benefit from a CMR-based approach assessing mechanical delay and tissue viability to guide LVC positioning.
Figure 1: examples of LVC optimality categories with bull’s-eye and 3D anatomical reconstructions indicating LMA and scar segments relative to LVC (pink lines). **Optimal** (top left): post-myocarditis cardiomyopathy (4.5% scar burden), LVC programming LV4-RV, 19.3% ESV reduction. **Semi-optimal** (top right): ischaemic cardiomyopathy (9.3% scar burden), LVC programming LV1-generator, 13.7% ESV reduction. **Suboptimal** (bottom left): idiopathic dilated cardiomyopathy (0% scar burden), LVC programming LV2-RV coil, -5.8% ESV reduction. **Unfavourable** (bottom right): post-myocarditis cardiomyopathy (5.2% scar burden), LVC programming LV1 tip-LV1 ring, -1.9% ESV reduction.
Figure 2: mean percentage ESV reduction across LVC-LMA, LVC-scar concordance groups (A and B) and the 4 categories of LVC topography optimality (C); *p<0.001 (one-way ANOVA).