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Revealing cardiac mechanics with CMR whilst CRT is active: the first step

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Introduction – Cardiac resynchronisation therapy (CRT) is a routine treatment for heart failure with reduced ejection fraction and conduction delay to improve symptoms and prognosis. Technological advancements both in cardiac magnetic resonance (CMR) and devices (MRI-conditional modes) now enable investigation of the haemodynamic response to CRT over a range of heart rates.

Methods - Patients with a CRT-D device were enrolled from heart failure clinics at a single tertiary centre. A complete device system assessment and baseline device check was conducted to ensure MRI compatibility and suitability. Left ventricular (LV) volumes and systolic blood pressure were measured at baseline and heart rates of 75, 90, 100, 115, 125, and 140 bpm (randomised order) with CRT active and intrinsic conduction (AOO). MRI conditional mode parameters were replicated through standard parameter modification to ensure biventricular pacing during CRT active scans. All scans were conducted using a 3.0 T Siemens Prisma MRI scanner with analysis on commercially available software. Contractility was derived from the systolic blood pressure and left ventricular end systolic volume. A post scan device and lead assessment was conducted to assess for scanning safety.

Results – Scanning was conducted in 22 patients (safety cohort). Post scan battery voltage reduced by 2.9±1.0%. Mean change in atrial, right ventricular and left ventricular lead impedance was 0.5±0.06%, 3.0±0.04% and -1.7±0.05% respectively. Mean change in atrial, right ventricular and left ventricular pacing threshold was 0.0±0.3%, 8.3±0.3% and 5.6±0.3%. No patient experienced symptoms related to scanning or device failure.

Preliminary data for patients with CRT on and off have been analysed (paired analysis cohort, n=8, 6 men). Mean age was 71.1±8.2, aetiology was primarily ischaemic (62.5%) with the remainder dilated cardiomyopathy. The mean LV ejection fraction at baseline was 29.4±12.9%. Biventricular pacing led to acute improvements in ejection fraction (p=0.005), left ventricular cardiac output (p<0.0001) and contractility (p=0.05) over the entire range of heart rates studied. We also noted an improvement in the force frequency relationship during biventricular pacing with a higher peak contractility (p=0.05), a higher heart rate at which this occurred (HR=130) and a generally up sloping relationship when compared with intrinsic conduction.

Conclusion – We have demonstrated for the first time, the mechanistic improvements in cardiac contractility consequent to CRT using CMR and also that MRI scans of conditional devices can be safe with CRT active.
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Fig 1: Paired cardiac parameters of 8 patients comparing CRT on (blue) and off (red) using CMR with standard error of means shown.