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HISTOLOGICAL VALIDATION OF DYNAMIC-EQUILIBRIUM CARDIOVASCULAR MAGNETIC RESONANCE FOR THE ASSESSMENT OF MYOCARDIAL EXTRACELLULAR VOLUME

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Introduction Extracellular matrix expansion is fundamental to left ventricular (LV) remodelling, and is a therapeutic target. Cardiovascular magnetic resonance (CMR) techniques are increasingly used to evaluate myocardial extracellular volume (ECV), however the most widely applied methods are without histological validation. The aim of this study was to provide whole-heart, histological validation of; 1. Dynamic-equilibrium CMR (DynEq-CMR), where ECV is quantified using haematocrit-adjusted myocardial and blood T1 values measured before and after gadolinium bolus; and 2. Isolated measurement of myocardial T1 at a fixed time-point following gadolinium bolus, used as an ECV surrogate.

Methods CMR was performed prospectively in patients awaiting heart transplantation. Of 54 patients on the transplant waiting list at a single UK Centre between 1 January 2011 and 1 July 2012, 41 had contraindications to CMR, 2 were too unwell and 2 refused consent. The remaining 9 underwent CMR, including modified look locker inversion recovery imaging at base, mid and apical LV levels before and 15 min after 0.2 mmol/Kg Gd-DTPA bolus at 1.5T, and same-day haematocrit measurement. Resulting pixelwise T1 maps (MatLab) were used to calculate segmental ECV. (Phantom studies performed prior to patient scanning determined T1 measurement accuracy and heart-rate correction algorithm.) 6 patients subsequently underwent transplantation (median interval between CMR and transplant 29 days). 16 tissue samples taken from each heart according to the 16-segment model (96 segments in total) were analysed for picrosirius red collagen volume fraction (CVF) (figure 1; pre-contrast (left) and post-contrast (middle) T1 maps and corresponding explanted heart tissue). The same CMR protocol was also performed in 10 matched healthy subjects.

Results DynEq-CMR-derived ECV was linearly related to histological CVF ($p<0.01$; within-subject $r=0.75$, $p<0.01$; $r2=0.56$;

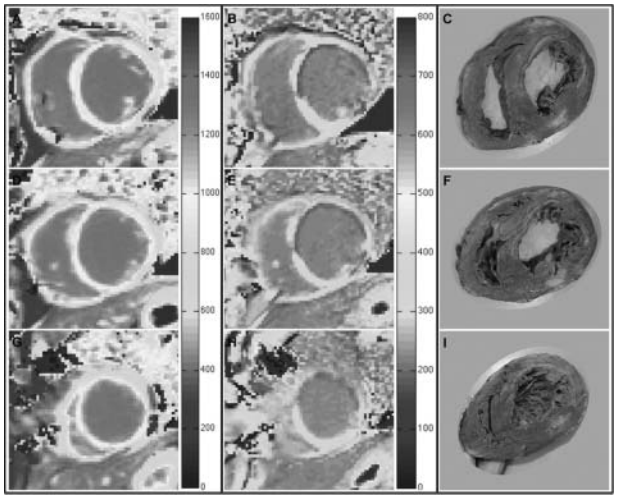

Figure 1

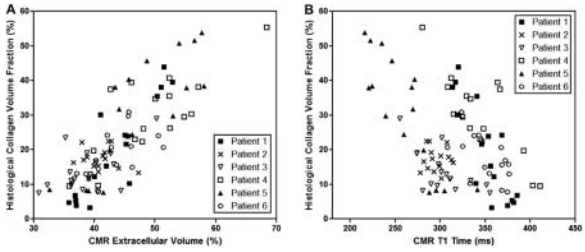

Figure 2

between-subject r=0.95, p<0.01, r2=0.89; linear regression equation: histological CVF=1.45×ECV–42, figure 2A). Correlation was maintained throughout the entire heart (ie, across all ventricular levels and septal and non-septal segments), and when segments displaying late gadolinium enhancement (LGE) were included and excluded. Isolated post-contrast T1 measurement showed significant within-subject correlation with histological CVF (r=−0.74, p<0.01; r^2=0.55), but between-subject correlations were not significant, likely reflecting between subject confounding factors such as renal function and body habitus (figure 2B). Pre-contrast T1 values and histological CVF were not significantly correlated. Mean segmental ECV in segments without LGE (41.4±5.0%) and with LGE (47.0±7.4%) were both significantly higher than in healthy subjects (25.5±2.6%; p<0.01).

Conclusions DynEq-CMR-derived ECV shows a good correlation with histological CVF throughout the whole heart. Isolated post-contrast T1 measurement is insufficient for ECV assessment.