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HIGH RESOLUTION 3D CINE IMAGING: A NOVEL APPROACH FOR AUTOMATED RIGHT VENTRICULAR PHENOTYPING

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Background Despite technological advances in cardiac imaging, accurate phenotyping of the right ventricle (RV) remains challenging. Current cardiac magnetic resonance (CMR) methods have poor through-plane resolution limiting the accuracy of modelling the complex RV shape and dynamics. RV function and mass are increasingly recognised as pivotal in guiding treatment and establishing prognosis in cardiomyopathies and pulmonary hypertension. Here we acquire high resolution 3D cine imaging of the RV and exploit the advantages of this approach with automated segmentation.

Methods We used a 1.5 T Philips Achieva system with a 32 element cardiac phased-array coil. 26 healthy volunteers from the GenScan (Genetic Studies of the Heart and Circulation) study were imaged.

Short axis SSFP images were acquired: 2D: voxel size $2.0 \times 2.2 \times 8$ mm, 12 sections, two sections per breath-hold, slice thickness 8 mm with 2 mm gap, 30 cardiac phases. 3D: single breath-hold 3D b-SSFP volumes: voxel size $2 \times 2 \times 4$ mm (reconstructed to $2 \times 2 \times 2$ mm), 48 sections, 20 cardiac phases, SENSE factor 4. Right ventricular 2D volumes were measured using CMRtools software. For the creation of the atlas each voxel in the 3D cine sequences obtained from five volunteers was manually labelled using ITKsnap software. Datasets from 21 other volunteers were non-rigidly registered to the 3D atlas. Images were segmented automatically using multi-atlas simultaneous segmentation and registration.

Figure 1

Figure 2

Results Presentation is confined to RV end-diastolic volumes (RVEDV) here. Data were log-transformed due to positive skewing (Normal plots, Shapiro-Wilk). 3D automated volumes were correlated with 2D manual volumes ($r_s=0.83$, $p<.001$, figure 1A). RVEDV (geometric means and 95% CIs) was greater when measured by 2D manual techniques (157, 144–172 ml) than by 3D automated techniques (144, 131–160 ml). One sample t test demonstrated a small, but statistically significant difference between transformed values (mean difference = -0.037 , $t=-4.256$, $p=.0004$). As a percentage of the mean absolute value, 3D volumes were 8% smaller than 2D manual volumes.

Discussion The 8% underestimation of RVEDV compared to manual volumetry represents a volume of 13 ml which we believe is of limited clinical significance. Furthermore visual assessment of 3D and 2D models derived from source data (figure 2) suggests that our approach tracks regional variations more accurately, which may indicate clinically significant subtypes in RV disease. We conclude that near-isotropic, whole heart, single breath-hold 3D cine imaging is a feasible approach for parametric modelling of the RV. This method is robust, quantitative and automated and suited to high-throughput population studies.