Cine-MRI vs. 2D-echocardiography to measure left ventricular function in rat heart in vivo

D. J. Stuckey[1], C. A. Carr[1], D. J. Tyler[1], and K. Clarke[1]
[1]Department of Physiology, Anatomy and Genetics, University of Oxford, Oxford, Oxon, United Kingdom

Two-dimensional echocardiography is the most frequently used non-invasive method for measurement of *in vivo* cardiac function in experimental animals (1). In humans, measurements of cardiac function made using cine MRI compare favourably with those made using echocardiography (2,3). However, no rigorous comparison of these two techniques has been made in small animals. Here, standard short axis 2D-echocardiography and cine-MRI measurements were made in the same control and infarcted rats.

Methods; Two dimensional echocardiography and cine-MRI were performed on two separate occasions on six control and six chronically infarcted female Wistar rats. Left ventricular short axis echocardiograms were acquired at the mid papillary level prior to and after MRI using a Philips SONOS 5500 system with a 12 MHz transducer. Rats were lowered into an 11.7 T (500 MHz) vertical bore magnet (Magnex Scientific, Oxon, United Kingdom), with a Bruker Avance console (Bruker Medical, Ettlingen, Germany) and a 60 mm birdcage RF coil (Bruker Medical, Ettlingen, Germany) as described (4). A contiguous stack of true short axis images were acquired from the base to apex of the left ventricle using an ECG-triggered FLASH-sequence (field of view 51.2 × 51.2 mm, matrix size 256 × 256, echo time/repetition time = 1.43/4.6 ms, 17.5° Gaussian excitation pulse, 28 to 40 frames per heart cycle slice). Heart rate remained stable throughout the procedure (controls, 393 ± 7 bpm; infarcts, 369 ± 7 bpm). Images were analysed using Scion Image (Scion Corp, Maryland) as described (4).

Results; Mid-papillary short axis images were acquired using both techniques (*Figure A*). Strong correlations for end diastolic area, stroke area and ejection fraction were found, however, cine MRI measurements of ejection fraction were 12 ± 6% higher than those made using 2D-echo. Repeated measurements on the same group of control rats made on separate days showed that the cine-MRI technique was more reproducible than 2D-echo (see Bland-Altman plot in *Figure B*). Power calculations suggest that 2D-echo would require five times more animals to find a statistical difference between groups. Analysis of individual cine-MRI slices indicated that left ventricular ejection fraction, end diastolic volume, end systolic volume and stroke volume changed considerably from the base to the apex of the heart. These differences were even greater in the infarcted heart and were related to the percentage of scar tissue (*Figure C*). From these data it was determined that a 1.5 mm difference in slice measurement position could result in a 15 ± 3% ($p < 0.0005$) change in ejection fraction. Therefore, a small (mm) difference in echo transducer positioning would result in a large difference in observed ejection fraction in the infarcted rat heart.

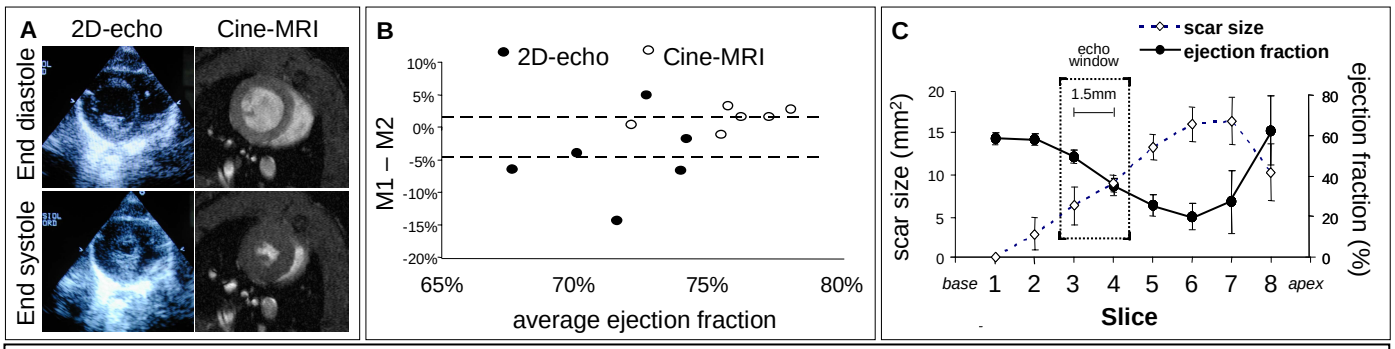

Figure – **A;** Mid-papillary short axis images acquired at end diastole and end systole using 2D-echoi and cine-MRI. **B;** Bland-Altmen plot illustrating method reproducibility. **C;** Cine-MRI measurements of regional scar size and ejection fraction acquired from the heart base to apex. The 1.5 mm "echo window" from which 2D-echo images were acquired is indicated.

Conclusions; Two dimensional echocardiography is commonly used to study cardiac morphology and function in small animals, as data can be acquired in real time and analysis can be performed quickly. However, caution should be taken when comparing functional results acquired using short axis 2D-echo vs. that acquired using cine-MRI. The accuracy of cine-MRI allows the identification of alterations in heart function that may be missed if using 2D-echo.

References

(1) Morgan *et al* (2004) *Am J Physiol 287*, H2049-53
(2) Keenan & Pennell (2007) *Echocardiography 24*, 185-93.
(3) Bellenger *et al* (2002) *J Cardiovasc Magn Reson 4*, 255-63.
(4) Tyler *et al* (2006) *J Cardiovasc Magn Reson 8*, 327-33.