Self-Gated MR Cardiac Imaging of Developing Chick Embryos in the Egg

W. M. Holmes[1], C. McCabe[1], B. Condon[1], J. M. Mullin[1], and M. M. Bain[2]

[1]Clinical Neuroscience, University of Glasgow, Glasgow, United Kingdom, [2]Veterinary School, University of Glasgow, Glasgow, United Kingdom

Introduction

The chick embryo is a well-known model for cardiovascular research, where it is commonly used for the study of cardiac development, though not to date cardiac function. In other animal models Magnetic Resonance Imaging (MRI) has evolved into a major non-invasive tool to study healthy and diseased hearts, for instance in assessing left ventricular (LV) function (ejection fraction, myocardial mass, wall thickness), infarct size and in assessing anatomical abnormalities. The lack of MRI application to chick embryos is partly due to the difficultly of monitoring chick ECG and respiration signals, which are conventionally essential in acquiring images free of motion artefact, by prospectively triggering the MR scanner. In this study we remove these obstacles by employing a self-gated CINE MRI protocol that incorporates a navigator-based retrospective gating technique. The navigator signal is retrospectively used to determine cardiac and respiratory cycles, allowing the MRI k-space data to be reorganised and reconstructed retrospectively, producing cardiac images that are free of motion artefacts. This ability to produce cardiac MRI images without the need for ECG or respiration sensors, has allowed non-invasive multislice imaging of the cardiac function of developing chick embryos in-ovo for the first time.

Method

The magnetic resonance imaging experiments were performed on a 7T Bruker Biospec system (Bruker Biospec, Karlsruhe, Germany), using a 72mm bird-cage RF volume resonator. The eggs used in this study were obtained from broiler breeder hens and were at day 20 of incubation (Stage 46). Each egg was placed into a custom-built polystyrene holder, which was suspended within the resonator/magnet in order to minimise vibrations arising in the gradient coils. A modified Flash sequence with a in-slice navigator echo was used for multislice CINE MRI. The analysis of the navigator echo and reconstruction of k space data was preformed using PavaVision Intragate (Bruker) software using Fourier filtering techniques [1]. The high quality images, with in-plane resolution of 300x300um and slice thickness 1.5mm, were then semi-automatically segmented with CAAS MRV FARM program (Pie Medical Imaging, Maastricht, The Netherlands), giving global heart parameters such as end-diastolic volume (EDV), end-systolic volume (ESV), ejection fraction (EF) and wall thickness.
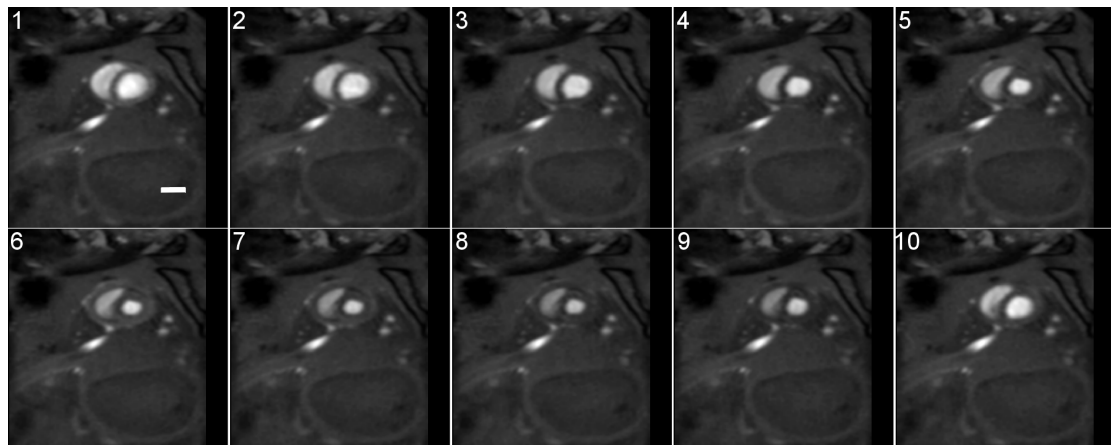
Results

Figure 1.   Short axis images showing the temporal evolution of the cardiac cycle taken from the central slice through the heart (Slice E, in figure 1). Image 1 shows end-diastole and image 7 end-systole, Slice thickness 1.5mm and in-plane resolution 300 x 300 μm. Bar = 5mm.

Conclusion

For the first time multi-slice CINE cardiac MRI images have been obtained for a chick embryo inside the egg. The use of a navigator echo to perform retrospective gating eliminates the need for ECG and respiration senses. This makes it possible to acquire high quality cardiac images non-invasively of the developing chick embryo inside the egg.

References

1. Heijman E, de Graff W, Niessen P, Nauerth A, van Eys G, de Graff L, Nicolay K, strijkers GJ. Comparison between prospective and retrospective triggering for mouse cardiac MRI. NMR Biomed. 2007; 20:439-447