A clover leaf coil array for neonatal cardiac imaging at 3T

D. Herlihy[1], D. J. Larkman[1], J. Fitzpatrick[1], A. Foran[2], D. A. Edwards[2], J. V. Hajnal[1]
[1]Imaging Sciences Department, MRC Clinical Sciences Centre, Hammersmith Hospital, Imperial College London, London, United Kingdom, [2]Department of pediatrics, Hammersmith Hospital, Imperial College London, London, United Kingdom

Introduction:

Cardiac MRI (CMRI) is rapidly becoming the investigation of choice in pediatric cardiology, and imaging at 1.5T offers clinicians improved visualisation and added functionality. However, there has been little research using 3.0T for CMRI. We have been interested in obtaining CMRI data on infants born prematurely in order to study cardiac function. These infants are vulnerable to myocardial dysfunction and CMRI offers the opportunity to study both the mechanisms of cardiac impairment and therapeutic interventions. The need for high signal to noise ratio (SNR) combined with a relatively small field of view (FOV), suggests that this application would benefit from higher field scanners, particularly if parallel imaging techniques using arrays of coils could be developed to improve speed and reduce motion artefacts. In this study we investigated a prototype 3 channel pediatric CMRI coil design for use at 3T.

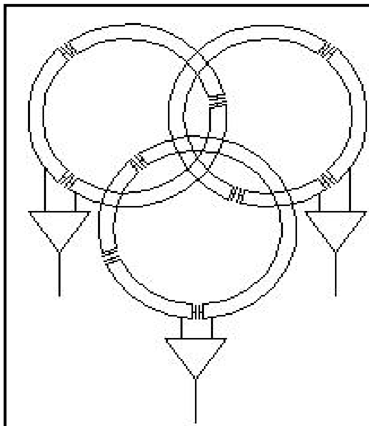

Figure 1. Cardiac Coil Layout

Coil design and methods:

The coil design is shown in Figure 1. It consists of a 3 loop “clover leaf” structure [1]. The circular loops were overlapped to minimise mutual inductance and their size of 6cm diameter was chosen to optimise sensitivity to the neonatal heart at a typical depth of 3cm. The loops are mounted inside a thermoplastic enclosure together with 50Ω input impedance pre-amplifiers (Pulseteq Ltd, Guildford, UK) which are protected at their inputs by ¼ wavelength diode switches and isolated at their output by semi-rigid based cable shield traps. The coils were actively decoupled during transmit using pin diodes. Diode driver and coil identification circuitry and additional cable traps were located in an enclosure adjacent to the coil. A diode malfunction test and an inductively coupled cable shield balun were implemented to ensure safe operation.

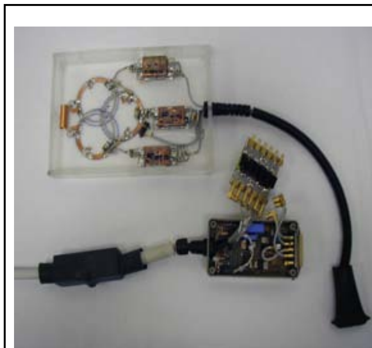

Figure 2. Coil assembly (connector box shown dismantled)

The coil was tested on a 3T Philips Intera system (Philips Medical Systems, Best, the Netherlands) on saline and oil filled phantoms and a neonatal subject (parental consent was provided in accordance with the Hammersmith and Queen Charlottes Ethics committee requirements). FFE sequences were employed for the phantom measurement with TR: 1000mS, TE: 10mS. For comparison SNR measurements were also taken with a standard commercial single loop Philips Synergy Flex coil M - the coil currently used for neonatal cardiac imaging. *In vivo* images were acquired using the standard neonatal cardiac protocol routinely used. The image shown in figure 4 is a balanced FFE with TR: 3.99mS, TE: 2mS, 45º, 256x256x32, 2 AVG using CLEAR reconstruction to produce an optimal SNR image across the field of view.

Results:

The design allows the coil to be padded and positioned on anterior chest wall with minimal disruption to the supine patient and no obstruction of monitoring equipment. Isolation between coils was -20dB or better. The architecture of the coil allows optimal imaging of the entire neonatal heart. From the oil phantom measurements snr was found to be 1.5 times the single loop coil at a depth of 3cm and 2.4 times at a depth of 1cm along the center line of the coil. The coils were equivalent at 53.4mm depth Figure 4 shows a typical single image from a multiphase bFFE.

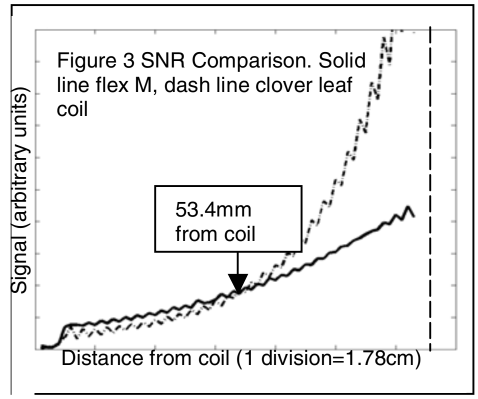

Figure 3 SNR Comparison. Solid line flex M, dash line clover leaf coil

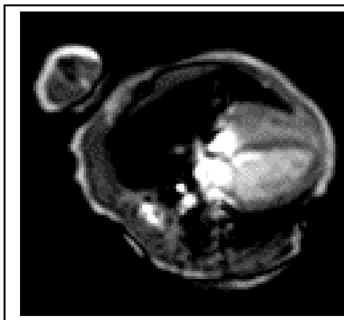

Figure 4 Neonatal Heart (bFFE) single frame from a multi phase acquisition

Discussion:

We have developed a 3 channel neonatal cardiac coil for use at 3T. Initial results suggest that this combination of coil and field strength will allow high resolution imaging of the neonatal heart. The small size of the individual loops relative to the RF wavelength at 3T reduced problems of designing coils at higher fields, but the coils are still sufficient in size to be body noise limited. The design appears to be flexible enough to accommodate a variety of body types while still providing significant local sensitivity in the region of the heart. An extension to this design would be to pair the existing 3 loop coil with a second similar coil which could be mounted posterior, this may increase SNR further in the anterior regions of the heart, decoupling may require low impedance preamplifiers to be incorporated into the design, this is the subject of further investigation.

Acknowledgement: We thank Philips Medical Systems for research grant support

References:[1] Roemer et al.’The NMR phased array’. Magn Reson Med. 1990 Nov;16(2):192-225