



Summary

MR imaging of the neonate is important clinically as this group of patients often have complex and multiple problems due to prematurity and developmental abnormalities. Their morbidity and mortality is reduced by prompt treatment but this is dependent on accurate and early diagnosis. Ultrasound imaging of the brain is the most widely used technique on neonatal intensive care units as it is portable and can be brought to the cot side. It does not require movement of the neonate from their incubator and controlled environment. However ultrasound does not detect some abnormalities detected by MR and if there is still doubt over the diagnosis MR imaging can be very helpful. In most units this involves moving the neonate away from their controlled environment to the scanner. We have overcome this problem in two ways:

1. A dedicated neonatal scanner situated on the intensive care unit.
2. A MR compatible incubator with a built in head coil that can be used as a transport incubator. We have reported our experience with a dedicated MR scanner before(1). In this study we present the results of our initial experience with the MR compatible incubator at 1.5T.

Methods.

Seven neonates were imaged at 1.5T without sedation or anaesthesia. Images were obtained using SSFSE,

3D-FT gradient echo and diffusion weighted sequences. In four cases time of flight angiography was performed.

Results.

All seven neonates were stable throughout the scan time (10-21minutes).

The images were graded by experienced observers as excellent or good. In no case was the image quality poor.

Conclusion.

Neonates can be imaged safely using a MR compatible incubator and fast image sequences. This method should allow neonates to be imaged by MR in sites where a dedicated MR scanner is not available.

References.

1. Whitby EH, Paley MN, Smith MF, Sprigg A, Woodhouse N, Griffiths PD. Low field strength magnetic resonance imaging of the neonatal brain. *Arch Dis Child Fetal Neonatal Ed* 2003;88(3):F203-8.

Ultrafast MR imaging of the non-sedated neonate using a MR compatible incubator.

EH Whitby, PD Griffiths, T Lonneker-Lammers, R Srinivasan, D Connolly, D Capener, MNPaley

Introduction

The premature neonate provides a challenge to modern medicine. New methods and technical developments are resulting in younger gestational age neonates surviving. They have multiple problems as they try to adapt to the world outside the protection of their mothers womb. Their surrounding environment needs to be carefully controlled as they cannot maintain homeostasis. However these neonates are at risk of numerous complications of prematurity. Early diagnosis and treatment reduce morbidity and mortality. Imaging is essential to diagnosis and MR is superior to ultrasound however imaging by MR necessitates movement of the neonate. Standard MR scanners are situated at a distant to the neonatal intensive care units and have a low ambient room temperature. In addition the neonate is moved several times during the journey to the scanner and into the scan room. Attempts have been made to use warming blankets and other instruments to maintain the temperature of the neonate and keep a constant humidity but there are problems with MR compatibility and standard equipment. Lammers Medical Technology have produced an MR compatible incubator with a built in head coil that can also be used as a transport incubator reducing the number of times the neonate is handled and transferred and maintaining the environmental conditions required by the neonate. Figure 1.



Fig 1. MR compatible incubator shown with the 'lid' open for access.

The aim of this study was to evaluate the combination of fast imaging methods and a MR compatible incubator at 1.5T to image non-sedated neonates.

Methods

LREC approval was obtained. Informed written consent was given by the parents. Seven neonates were imaged at 1.5T (Eclipse, Philips medical systems) in a MR compatible incubator (Lammers Medical Technology), figure 2, using fast imaging techniques (T1, SSFSE, 3D-FT gradient echo T1 images and Diffusion weighted imaging) and in 4 cases time of flight angiography. No sedation or anaesthesia was used.

Imaging sequences:

A standard spin echo T1 weighted sequence was acquired with TR=400ms, TE=16ms, SLT=4mm, in-plane resolution = 0.9mm, NEX=2. The T2 weighted SSFSE sequence used TR=2000ms, TE=75ms, in-plane resolution=1mm, SLT=5mm, ETL=132, NEX = 1. The 3DFT gradient echo sequence used RF spoiling and had TR=238 ms, TE=3.4 ms, in-plane resolution=0.9mm, SLT=6mm, NEX=2, FA 70°. Diffusion weighted imaging used TR=3000ms, TE=100ms, in-plane resolution = 2mm, SLT = 5mm, ETL=64, NEX=1, b = 1000mm⁻². The SLINKY angiography sequence was acquired with TR=29ms, TE=6.7ms, in-plane resolution = 0.43mm, SLT=1mm, NEX=1, FA=33°, MRV sequence used TR=27, TE=6.7, FOV 20, matrix 256x512, SLT=2.5mm.

A custom built incubator with temperature and humidity control and a dedicated phased array receiver coil (Advanced Imaging research) were used. The neonates were monitored throughout using MR compatible pulse oximetry. The temperature and humidity of the incubator were maintained appropriate for the needs of the neonate and monitored throughout.

The images were scored for quality by 2 neuroradiologist and 1 neonatal radiologist and a radiological diagnosis was reached by consensus in each case.

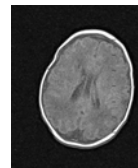


Fig 2 Normal T1 RF Fast

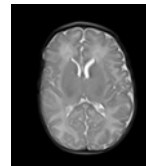


Fig 3 Normal T2 SSFSE

Results

The neonates were aged 2 days to 4 months from birth and ranged from 24 weeks gestational age to term at birth.

They were all stable neonates imaged prior to discharge home from the unit.

The neonates remained stable throughout the scan time (range of 10-21 minutes). Good or excellent T1 and T2 weighted images were obtained in all cases. T1 data was best obtained from a spin echo sequence (acquisition time of 2m46s) and T2W from SSFSE (20s), fig 2 fig 3. MR angiography was successful (fig 4) in the 4 cases attempted. Diffusion weighted imaging was successful and gave good quality images (fig 5) as did the FLAIR sequence (fig 6).

Final diagnoses were normal (3), subdural haematoma (3), and germinal matrix haemorrhage (1).

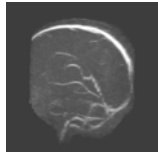


Fig 4. Normal MRV

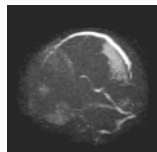


Fig 4b MRV and subdural haemorrhage

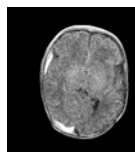


Fig 5. T1 SDH

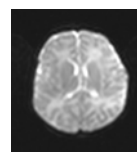


Fig 6 Normal DWI

Discussion

Fast imaging methods and a dedicated MR compatible incubator/coil allow safe and efficient MR imaging of the non-sedated neonate. The constant environment reduces the risk of adverse events occurring during the transport and imaging of the neonate and essential, information aiding management could be obtained from the imaging process.

There have been several attempts to overcome the problem of imaging the neonate including dedicated scanners on neonatal intensive care units both in our institution and others. In general these dedicated units are ideal as they have an ideal geographical situation and are flexible to the needs of the neonate. However they are not widely available and may be restricted in their image sequences. The neonatal incubator used in this study would allow sites without a dedicated MR scanner to image neonates safely. There are still a few problems, the neonate is not easily visible from the control room and it is safer to have a member of staff in the room throughout the scan. The incubator controls temperature and humidity but additional monitoring is required for ECG, and oxygen saturation. In this study we used MR compatible pulse oximetry (MR 3500, MR Resources Inc., USA), used in our dedicated MR scanner.