A Dedicated 1.5T NICU MR System

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Introduction:

MR imaging of young and adolescent patients to diagnose diseases is well-established. However, MRI is not widely used for Neonatal Intensive Care Unit (NICU) patients, due to the lack of supporting infrastructure and associated logistical challenges. Specifically, MR scanners are typically located in remote Radiology departments and few dedicated coils exist. Consequently, X-Ray and Ultrasound are often the only choices for imaging neonates. To obviate the challenges of siting and operating a conventional MR scanner in the NICU, we developed a small-footprint 1.5 Tesla superconducting system designed specifically to accommodate the special needs of the neonatal population and the space constraints of the NICU. In this abstract, we describe a 1.5T small-bore MR system with a customized patient handling system that has all of the advanced imaging capabilities of a high-end adult-sized MR scanner. This system interfaces a GE 430s Optima magnet designed for orthopedic use with GE HDx electronics found on conventional large-bore systems. The hybrid system is installed in a level 4 NICU at our institution.

Materials and Methods:

A standard GE MR 430s Optima (ONI) system was installed in our NICU. The magnet was raised to a height of 1 meter and leveled. The basic system was then enhanced with imaging electronics from a conventional large-bore MR scanner (GE Healthcare, Waukesha, WI). The system integration allows imaging with either the HDx hardware or the standard GE MR 430s Optima hardware. In each modes of operation the GE MR 430s Optima magnet, gradient coils, and gradient amplifiers are used (Figure 1). To switch between system electronics, the gradient amplifier inputs are routed at a patch panel to the appropriate system electronics, and the RF coil is attached to the appropriate quad hybrid. Birdcage imaging coils from the Optima system are used. The largest imaging coil has an inner diameter of 18 cm, which is large enough to accommodate more than 90% of the patient population served by our NICU according to an internal clinical database of N=1613 patients. The patient handling system consists of a table with four wheels. On top of the table is a movable platform on rails, which can be locked in position. This movable part has receptacles for different sizes of patient supports (half-pipes) to accommodate the different size neonates and imaging coils (14.5, 16 and 18 cm in diameter). Overall dimension of the patient handling system are: 36 inches long, 18 inches wide and about 33.5 inches high.

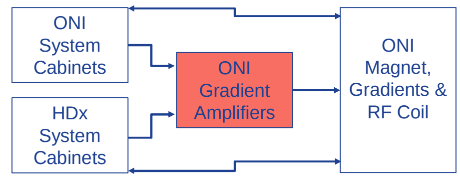
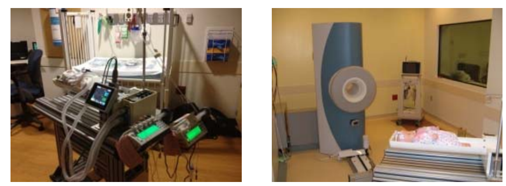


Figure 1: *Block diagram of ONI/HDx system integration.*

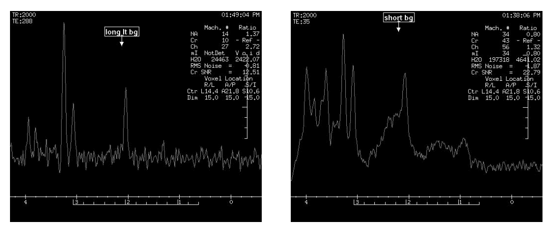
For the MR exam the neonate is transported to the MR control room in his/her crib. In the control room, the patient is transferred onto the half-pipe of the patient handling system. The baby is secured in the half-pipe. Ear plugs and earmuffs are placed onto the patient for hearing protection (Figure 2a)). The patient is then wheeled into the screen room to the magnet (Figure 2b)). The table is docked to a belt-driven mechanism that is powered by a stepper motor. The movable platform with the half-pipe is manually pushed towards the magnet, cantilevering the patient in front of the magnet. As with a conventional large-bore system, a land-marking laser is used to identify the anatomic region of interest. After land-marking, the patient is automatically advanced to the magnet's isocenter as on a conventional adult sized scanner (under the control of the HDx system software). As with conventional scanners, the system-controlled stepper motor is used to bring the prescribed anatomy to magnet isocenter for each image acquisition in the series.



a) **b)**

Figure 2: *Images of a) patient preparation for scanning in control room, b) NICU MR system.*

Preliminary MR imaging exams to demonstrate scanner performance and safety were obtained in N=15 medically stable babies under an IRB protocol. Subsequent routine clinical patient exams of the brain, spine, abdomen and/or chest using the hybrid system (i.e. employing the advanced imaging electronics) are being performed under a second IRB protocol. The MRI protocols used to perform the routine clinical NICU exams are identical to those used to scan neonates on the adult sized scanners at our institution.



a) **b)**

Figure 3: *Spectra Probe Press a) long TE, b) short TE.*

Results and Outlook:

Figures 3 and 4 show the results from typical clinical brain examination performed with the new system on two different babies. The results of spectroscopy examination performed in a neonate suffering from seizures of unknown etiology using a PROBE PRESS sequence with a long echo time (TE=288ms) and a short echo time (TE=35ms) are shown in Figure 3. A lactate peak was not apparent in either of the spectra.

Figure 4 shows a representative late echo image acquired in a neonate following a myelomeningocele repair using a dual fast spin echo sequence with TR=3666.7ms, TE=120ms, NEX=2, a matrix of 256x192 with a field FOV of 16x12 cm.

Standard imaging protocols were successfully used to image NICU patients utilizing a dedicated patient handling system and a small-bore 1.5T superconducting magnet located in the NICU. The integration of advanced imaging hardware with the small bore magnet enables all of the advanced imaging capabilities typically of a high-end adult sized system. Designing the patient table as an integrated part of the neonatal MRI system provides an easy workflow for scanning and for transferring the patient and associated monitoring and life support equipment onto the patient handling system. The flexibility of the longitudinal half-pipe positioning allows scanning of all anatomical regions of neonatal anatomy. *In-vivo* exams show image quality and signal to noise ratio comparable to a conventional large bore MR system. Further development will focus on temperature control for those neonates who are not able to maintain their body temperature.

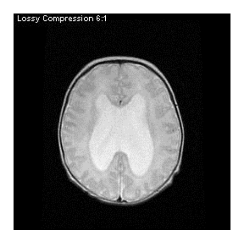


Figure 4: *Neonate in-vivo brain image.*