Pulmonary MRI in Neonatal Medicine

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Purpose: To assess the ability of a new neonatal MRI scanner to quantify parenchyma and interstitial lung water content and to diagnose pulmonary abnormalities.

Methods: MR imaging was performed on two identical small footprint (21.8 cm diameter bore without RF coil; 51.8 cm long) 1.5T MR systems designed specifically for imaging neonates[1,2]. One scanner is preclinical and devoted to research; the other is located within the neonatal intensive care unit (NICU). Two sets of imaging studies of the lung were performed. In the first, 5 premature sheep, delivered at 85% gestation, were imaged at two time points over the first six hours of life on the preclinical scanner (approximately 2 hrs and 4.5 hrs post-delivery). Ventilation was maintained during image acquisition. For the second arm of the study, three infants with putatively normal lung function, but undergoing MRI for neurological abnormalities, and one infant with a pleural effusion were imaged free breathing and without sedation on the neonatal MRI system installed within our NICU. IACUC and IRB approvals were obtained prior to the initiation of the sheep and human studies, respectively; written informed consent was obtained from the parents prior to imaging. Spin echo (SE, TR/TE=400/14ms), fast spin echo (FSE, TR/TE=3000/80ms, ETL=8), and gradient echo sequences (GRE, TR/TE≈12.7/1ms, FA=7) were used to evaluate the lung in the sheep and human neonates. Quantitative assessment of lung water content in parenchymal areas in the sheep was performed in FSE images, and parenchymal signal in the human neonates was performed in the GRE images. (Multiple ROIs away from major vessels were used in all cases.) The neonatal images were also evaluated by a pediatric radiologist.

Results: All sheep and infants successfully completed the MR exams, and diagnostic quality images were produced, with some respiratory and cardiac-motion artifacts. The signal in the lungs of the sheep was highly heterogeneous reflecting the regional differences in fluid content, which was in part position dependent. In addition, regions of atelectasis and the gradual elimination of the fluid from the lungs during the first few hours of life were visualized and measurable in T_2 weighted FSE images (Figure 1). The time course and degree of the fluid elimination was animal and regionally dependent, but could be quantified and characterized for each region within each animal. Overall, the reduction in the lung signal (normalized to muscle) between the two time points, averaged across all regions and animals, was measured to be 40% ± 25%. In humans, normal parenchyma was measurable in short TE GRE images (36% of the muscle signal in the control lungs for ROIs away from major vessels). In the one case of chylous pleural effusion, increased water content and atelectasis were well visualized in the SE and FSE images (Figure 2), though normal parenchymal signal was low (as expected). A moderate-sized right hydropneumothorax was apparent (air—green arrow; fluid—yellow arrow, Figure 2) in the axial T_2 weighted FSE images, as was a small left pleural effusion (white arrow). Scattered areas of increased signal in the perihilum on the right (red arrow) probably represent bronchovascular crowding due to atelectasis.

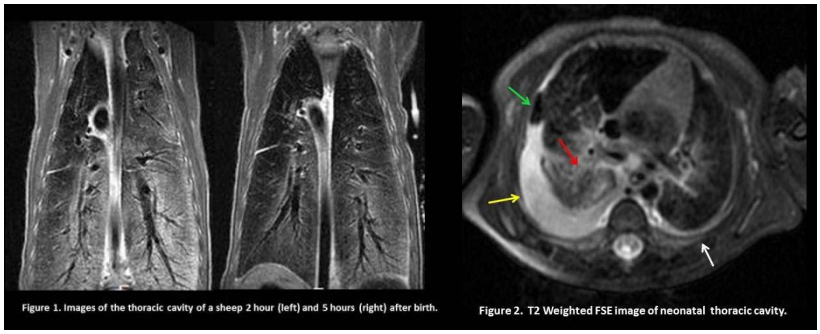

Figure 1. Images of the thoracic cavity of a sheep 2 hour (left) and 5 hours (right) after birth.

Figure 2. T2 Weighted FSE image of neonatal thoracic cavity.

Discussion: Respiratory pathologies are often present in premature infants. Pulmonary MRI has the potential to provide detailed diagnostic information about pulmonary anatomy and function. The results of this study demonstrate that *in-situ* pulmonary MRI within the NICU environment is feasible and diagnostic-quality images can be acquired with no ionizing radiation or sedation. The inclusion of respiratory-gated and UTE sequences will improve image quality in the near future[3,4].

Conclusion: The neonatal system is a viable platform to obtain detailed diagnostic thoracic MRI in the neonate, to perform longitudinal studies of normal and abnormal lung development, and to evaluate treatment response to therapy within the NICU.

References: [1]Tkach JA, et al. 2012 Ped Rad (2012) 42:1347-1356, [2]Tkach, JA et al. AJR (In Press), [3]Lederlin M, Crémillieux Y JRMI. 2013 Oct 10. Doi 10.1002/jmri.24429, [4]Johnson KM et al, MRM. 2013 Nov;70(5):1241-50.