

Hyperpolarized Helium-3 MR Imaging of a Non-Sedated Infant: A Proof-of-Concept Study

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Background: Although the most common chronic disease of childhood is lung disease, methods for its assessment, such as spirometry, cannot be performed by young children. CT provides information about alterations in lung structure but the relatively high radiation dose limits its utility, particularly in young children who are far more likely than adults to develop radiation-induced malignancy. Clinical trials of treatments for lung disease are difficult to perform in the absence of a quantitative outcome. Hyperpolarized helium-3 (HHe) is a non-radioactive, relatively biologically inert, gaseous contrast agent for MRI that, when inhaled, provides images of lung ventilation with high spatial and temporal resolution. In adults and older children, imaging is typically performed during a breath hold following the inhalation of HHe.

Purpose: To develop an imaging protocol, including MR pulse sequences and gas-delivery methods, for HHe MR ventilation imaging that can be used to successfully image the lungs of non-sedated infants.

Methods and Materials: We performed HHe MR imaging in a single non-sedated, healthy 13-month-old infant under an IRB and FDA approved protocol. Helium-3 gas was polarized using a home-built optical-pumping and spin-exchange system to achieve polarizations between 50% and 60% (1). Imaging was performed on 1.5T whole-body MRI system (Avanto, Siemens Healthcare, Malvern, PA) using an adult-sized, flexible wrap, transmit/receive RF coil tuned to the helium-3 frequency (Clinical MR Solutions, LLC, Brookfield, WI). Contiguous 2D-spiral helium-3 images were acquired sequentially during HHe administration using the following parameters TR/TE 8.1/0.9 ms; FA 20°; 3.3x3.3x10-mm spatial resolution; 0.12s/slice. The total scan time for the 5 slices required to cover the lung was 0.6 s. A large in-plane field-of-view was used to ensure the infant would be within the field-of-view even if they moved during the acquisition.

The RF coil was wrapped around a hollow cylindrical-shaped loading phantom and placed in the center of the scanner bore. Shortly before the HHe MR acquisition, a 500-mL plastic bag (Jensen Inert Products, Coral Springs, FL) was filled with HHe and attached, via a small plastic straw, to the medication port of a pediatric-sized ambu bag. Immediately before imaging, the non-restrained infant was placed supine within the load, inside of the RF coil. The spiral acquisition was started and a pediatric facemask attached to the ambu bag was placed over the infant's nose and mouth. A few small puffs of air and HHe were administered to the infant during the acquisition. The infant was then removed from the scanner. Total time in the scanner was a few minutes. The infant cried transiently during the procedure but otherwise tolerated it well.

Results and Discussion: To our knowledge, this is the first report of HHe MRI of infant lungs. Using a simple gas delivery system, sufficient HHe to provide adequate signal for imaging was inhaled by the non-sedated infant, Figure 1. The infant lungs filled homogeneously with HHe, similar to prior results with healthy children and young adults. The SNR in central slices was ~50, which is surprisingly good considering an adult-sized helium RF coil was used. An infant-sized RF coil could be expected to increase SNR by a factor of 2-4. Although the infant was in motion during the acquisition, minimal motion artifacts were observed in the images. We feel a very short acquisition time is crucial for imaging non-sedated infants to, in essence, freeze motion. In addition, the relatively low sensitivity of the spiral pulse sequence to motion was likely an important factor for obtaining high-quality images.

Conclusion: These results demonstrate the feasibility of HHe-MRI in non-sedated infants.

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References: 1. Mooney KE et al. ISMRM 2009; 2166.

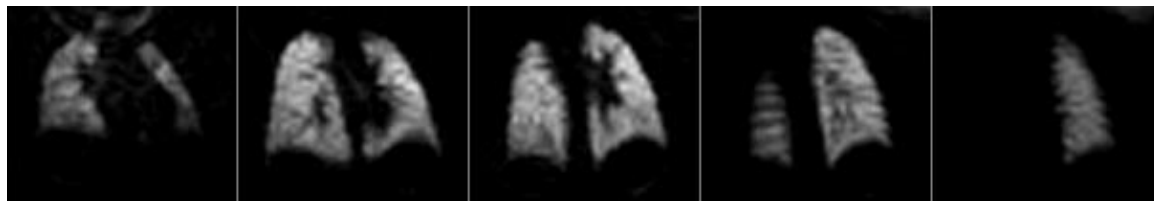


Figure 1: HHe coronal MR images of a healthy 13-month-old non-sedated, non-restrained infant. The lungs are well ventilated throughout. Motion artifacts are minimal despite patient movement during the image acquisition. Some residual HHe in the apparatus used to deliver the gas can be seen superiorly on the anterior most image (left).