5-minute non-sedated neonatal and pediatric pulmonary UTE based MRI studies

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Highlight:

Pulmonary MRI is free of ionizing radiation, which is beneficial for screening and longitudinal imaging in radio-sensitive populations, like newborns and children. However, practical considerations make pediatric pulmonary MRI challenging, including smaller body size, increased respiration rate, and increased motion from inability to hold still. In this work, we propose an optimized 5-minute non-sedated neonatal and pediatric pulmonary UTE, applied on seven patients.

Introduction:

Computed tomography (CT) is the standard and widely used imaging technique for assessing lung anatomy, due to short scan times and high spatial resolution. But CT inevitably induces radiation exposure to patients, which is particularly concerning for neonatal and pediatric patients[1]. MRI would be an alternative choice for neonatal and pediatric pulmonary screening, and its flexibility also lends itself to further tissue characterization and testing of cardiac function.

However, lots of challenges make neonatal and pediatric pulmonary MRI difficult. First of all, low proton density and short T2* properties largely reduce the parenchymal signal[2]. In addition, compared to CT, MRI requires a much longer scan time, which makes pulmonary MRI vulnerable to subject motion artifacts, especially from respiratory motion[3,4]. Recently, ultrashort echo time(UTE) acquisition schemes combined with motion correction strategies have been applied to pulmonary imaging in adults[5,6]. UTE overcomes the fast signal decay in lung parenchyma and motion correction allows free breathing scans. As for neonatal and pediatric pulmonary MRI, it is more challenging, especially for non-sedated free breathing scans. Unlike adults, it is difficult for children to keep still during a long scan and their respiration rates tend to be higher and less regular. Therefore, a limited scan time and motion robust imaging techniques are required. Additionally, most MRI hardware and software are designed with adult anatomy and physiology in mind, so these factors should also be optimized to suite the unique anatomy and physiology of children[1].

In this work, we propose a 5-minute non-sedated pulmonary MRI strategy based on some practical considerations in neonatal/pediatric MRI. We compare the differences between adults and pediatric studies from technical aspects, then present cases with age range from several week-old newborns to teenagers, and qualitatively compare MR scans with other product sequences, and standard clinical CT scans.

Methods:

Patient recruitment

Pediatric and neonatal patients were recruited for MRI, with Institutional Review Board approval and parental informed consent.

Acquisition, Motion Correction and Reconstruction

All the studies were run on clinical 3.0 T scanners (MR750, GE Healthcare, Waukesha, WI), having patients free breathing and without sedation. 3D 5min UTE sequence[7] with golden angle ordering, and variable density readout acquisition was used for all the scans. A Self-navigator strategy was applied for tracking respiratory motion. Data with large drift in the self-navigator signal, induced by bulk motion, was removed. Then, a soft-gated reconstruction method[4,8] was used for 3D high SNR motion corrected exhale state image.

Results:

5-min free breathing UTE scans from seven subjects, including two newborns (< 1 month old), one 4-year-old and two 5 year-old kids, and two teenagers, are shown in Figure1. With optimized sequence, parameter selection, and motion correction, the images show high SNR and clear small structures (vessels and airways) in the lung.

Conclusion:

In this work, we discuss the practical considerations in neonatal and pediatric pulmonary MRI studies. Compared to adult scanning, imaging parameters, hardware setups, and motion correction need to be optimized. Our proposed 5-min free breathing non-sedated neonatal and pediatric lung UTE are highlighted, and applied to patients varied from newborns to teenagers. This approach was successful even with unsedated 4 and 5 year olds who often have trouble staying still during scans. The UTE images have high SNR and resolution in lung showing potential for a broad range of clinical applications in pediatrics and neonatology.

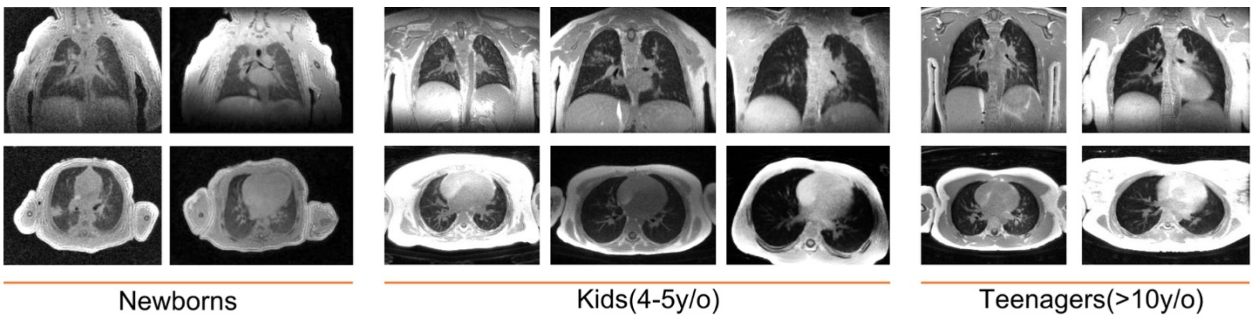

Figure 1. Example images from seven pediatric/neonatal studies. For each case, two slices(coronal and axial) from 3D UTE images are shown, and subjects are binned to three groups based on age. Newborns were scanned with 8-channel head coil array, with 1mm isotropic resolution. Kids were scanned with 32-channel cardiac array or 12-channel in Figure 1, with 1~1.2mm resolution. Teenagers were scanned with 8-channel cardiac array, with 1.1 to 1.4mm resolution.

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