Pediatric Chest MR Imaging: Lung and Airways

Juan C. Baez, MD[a,b], Pierluigi Ciet, MD, PhD[c,d], Robert Mulkern, PhD[b], Ravi T. Seethamraju, PhD[e], Edward Y. Lee, MD, MPH[b,*]

KEYWORDS

• MR imaging • Lungs • Airways • Pediatric patients

KEY POINTS

- Magnetic resonance (MR) imaging can reliably identify lung nodules larger than 5 mm in children.
- MR imaging can permit accurate and dynamic evaluation of large airways.
- MR imaging is a valuable imaging modality to assess the progression of chronic lung diseases such as cystic fibrosis.
- Future chest MR imaging techniques have a great promise for functional imaging of the lungs in pediatric patients.

INTRODUCTION

In recent years, MR imaging with advanced imaging techniques has been receiving a lot of attention mainly because of its ability to assess lungs and airways in the pediatric population. Although computed tomography (CT), which is regarded as the gold standard imaging modality, provides exquisite resolution of the anatomic structures of the lungs and airways, it exposes the pediatric patient to ionizing radiation. MR imaging has been advocated as an adjunctive tool, particularly in pediatric patients, for the evaluation of chest pathology. In the past, the proton-poor environment, rapid signal dephasing, and respiratory motion presented significant obstacles for widespread adoption and clinical use of MR imaging lung studies. Nevertheless, by optimizing protocols and tailoring them to the individual pediatric patient and with the clinical question at hand, MR imaging can now provide excellent visualization of the relevant anatomy and pertinent abnormalities. The future of chest MR imaging includes a greater emphasis on functional information. The use of hyperpolarized gases, where available, provides excellent imaging of lung ventilation. Upcoming technologies, such as Fourier decomposition, promise the ability to provide functional perfusion and ventilation data without the use of intravenous or inhaled contrast agents. The overarching goal of this article is to provide up-to-date information regarding MR imaging techniques for practical assessment of lungs and airways in the pediatric population. Furthermore, several pediatric thoracic disorders involving the lungs and airways that can be evaluated with advanced MR imaging techniques are highlighted.

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[a] Mid-Atlantic Permanente Medical Group, 2101 East Jefferson Street, Rockville, MD 20852, USA; [b] Department of Radiology, Boston Children's Hospital, Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115, USA; [c] Department of Radiology and Pediatric Pulmonology, Sophia Children's Hospital, Erasmus Medical Center, Wytemaweg 80, 3015 CN, Rotterdam, The Netherlands; [d] Department of Radiology, Beth Israel Deaconess Medical Center, Harvard Medical School, 330 Brookline Ave, Boston, MA 02215, USA; [e] Magnetic Resonance, Research and Development, Siemens Healthcare, 1620 Tremont St., Boston, MA 02120, USA

* Corresponding author. Department of Radiology, Boston Children's Hospital, Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115.

E-mail address: Edward.Lee@childrens.harvard.edu

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EVALUATION OF LUNG PARENCHYMAL ABNORMALITIES

MR Imaging Protocol

A fundamental MR imaging protocol evaluating the lung parenchyma includes a gradient recalled echo (GRE) multiplanar localizer, coronal T2 single-shot half Fourier turbo spin echo (HASTE), axial 3-dimensional (3D) GRE T1, coronal balanced steady-state free precession (true fast imaging with steady-state precession), and axial short tau inversion recovery.[1,2] One can complete this practical MR imaging examination in less than 25 minutes. If necessary, postcontrast imaging with a 3D GRE T1-weighted sequence with fat saturation can provide information regarding enhancement characteristics. Pediatric patients with difficulty after breathing instructions because of their young age or critical condition often benefit from a sequence that does not rely on breath holds such as an axial T2 periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER/BLADE) performed with the patient free breathing.

Consolidation and Infection

Although CT remains the gold standard for evaluation of parenchymal lung abnormalities, the ability to characterize lung abnormality without exposing the child to ionizing radiation has propelled research into the use of alternative technology.[3] Several studies have shown that ultrasonography can diagnose peripherally located lung consolidation as well as or better than radiography.[4–6] However, chest ultrasonography becomes more difficult with increasing age because the acoustic windows become more limited with increasing ossification of the skeletal structures.[7] Furthermore, deep parenchymal abnormalities surrounded by aerated lung go undetected by ultrasonography because of dissipation of the ultrasound beam by the air interface. For these reasons, the use of MR imaging to aid in the diagnosis of lung abnormalities has been evaluated by multiple investigators.[8,9] Although CT provides greater spatial resolution than MR imaging, the use of multiple sequences offers characterization of tissue beyond the limits of CT.[10]

Studies have shown that MR imaging can detect pneumonia and other consolidative processes in the lungs (**Figs. 1** and **2**). A prospective study comparing 1.5T MR imaging using fast T1 and T2 imaging sequences with radiography for the detection of pneumonia proved that the 2 modalities were comparable.[11] A comparison of different MR pulse sequences showed that HASTE was the best sequence for the detection of lung consolidation.[2] In addition to the consolidation, MR imaging can also detect complications of pneumonia such as necrosis/abscess and pneumonia.

Other studies have compared MR imaging with CT, the current gold standard, and shown that the former is a high-sensitivity examination for evaluation of lung abnormalities. In one recent prospective trial of 71 pediatric patients in which patients underwent both CT and MR imaging evaluation within 24 hours, diagnostic accuracy of MR imaging was 97% compared with that of CT. The only undiagnosed lung findings were a single case of mild bronchiectasis and another case with a pulmonary nodule measuring 3 mm that went undetected.[12] In addition, this study demonstrated excellent interobserver reliability between 2 readers, suggesting the robustness of this technique.

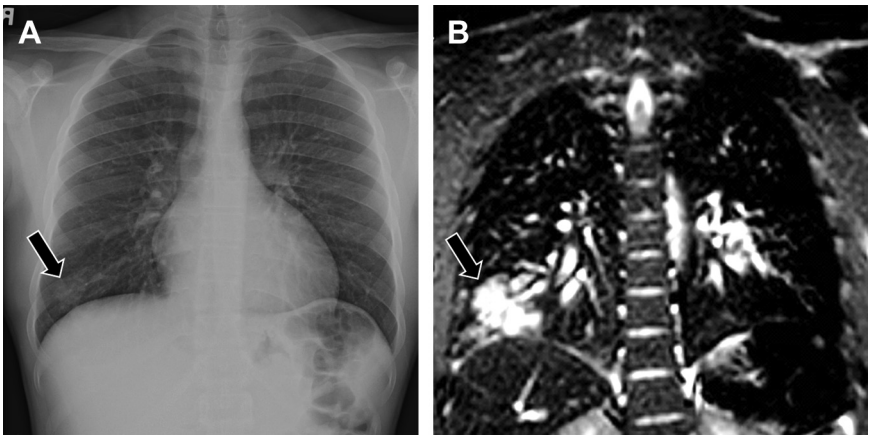

Fig. 1. Pneumonia. (*A*) Frontal chest radiograph demonstrates focal consolidative opacity (*arrow*) in the right lung base. (*B*) Coronal short tau inversion recovery MR image demonstrates a T2-hyperintense focus (*arrow*) in the right lower lobe corresponding to the consolidative opacity (see Fig. 1*A*) in this region.