Pediatric Emergency Magnetic Resonance Imaging

Current Indications, Techniques, and Clinical Applications

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KEYWORDS

• Children • Pediatric emergency • Trauma • Appendicitis • Stroke • Sinus thrombosis • Meningitis • Abscess

KEY POINTS

- MR imaging is valuable in the confirmation and characterization of emergent pediatric disorders because of its ease of performance, superior soft tissue contrast, multiplanar capabilities, lack of ionizing radiation, and ability to detect multiple lesions with minimal patient manipulation.
- Emergent MR imaging can be critical when clinical, laboratory, and ultrasound or computed tomography findings are nonspecific.
- Recognition of some of the characteristic imaging features of emergent pediatric disorders is important because it can allow rapid institution of therapy, which reduces morbidity and mortality.
- MR imaging can be an effective and efficient method for the timely and appropriate management of pediatric disease entities that can occur in the emergent setting.

INTRODUCTION

MR imaging in the pediatric population can be difficult to obtain because of noise, fear, claustrophobia, and inability to remain motionless. Sedation or general anesthesia is often required to obtain quality images. Despite these limitations, the uses of pediatric MR imaging have expanded over time to include a growing number of emergency indications. This shift is a reflection of the intrinsic advantages of MR imaging in depicting soft tissue disease processes and bone marrow edema as well as the heightened awareness of radiation exposure associated with alternative workup strategies that use computed tomography (CT). Additionally, rapid MR imaging protocols have reduced the length of MR imaging examinations while still obtaining clinically usable information.[1] The use of single-shot fast spin-echo (SSFSE) MR imaging, for example, has been shown to be useful in the evaluation of ventriculostomy shunt malfunction in children treated for hydrocephalus. Similarly, rapid protocols can also be used to diagnose appendicitis without the need for CT imaging. In this article, the authors discuss a variety of pediatric emergencies that can be diagnosed with MR imaging and review the clinical features that are specific for each disease entity.

The authors have nothing to disclose.

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IMAGING TECHNIQUE

Pediatric magnetic resonance (MR) evaluation in the emergent setting is typically performed on a 1.5T or 3T MR scanner with patients supine, using a phased array receiver coil. Higher field strength imaging on a 3T MR scanner offers several benefits for pediatric imaging, including improved signal-to-noise ratio (SNR) and contrast-to-noise ratio, with potential for improved spatial and temporal resolution.[2,3] However, 3T MR imaging also has disadvantages that can be particularly challenging for abdominal imaging, including increased susceptibility artifacts from air within bowel loops as well as increased energy deposition, which can approach patients' specific absorbed ratio limits in children. Nevertheless, the current trend in academic centers in the United States is toward higher-field-strength pediatric MR imaging.

The receiver coil used for pediatric MR depends on the body part being imaged. For brain imaging, a 32-channel head coil is typically used at the authors' institution. For spine imaging, whole-body coils that include coil elements embedded in the scan table are used. The receiver coil used in pediatric musculoskeletal imaging also depends on the body part being imaged, with either a flex coil or a whole-body coil in combination with a body matrix coil used. The receiver coil for pediatric abdominal imaging should fit snugly around patients to maximize spatial resolution and SNR. This fit can be difficult, as various adult MR coils need to be fitted to pediatric patients ranging from infants to adolescents. A head coil is often used for infants and small children, whereas a body coil is typically used for larger children and adolescents.[4] Whole-body coils have also been used with success.

Compared with adult imaging, patient motion is a more substantial problem with pediatric MR imaging. Sources of motion include voluntary motion from patients' muscular movements in the scanner as well as involuntary motion predominantly due to respiratory motion in children unable to suspend respiration on command. In order to minimize scan times, parallel and fast imaging techniques can be used.[5] An additional consideration unique to children is the prevalence of orthodontic hardware, the presence of which can render susceptibility-weighted imaging (SWI) and diffusion-weighted imaging (DWI) nondiagnostic. Therefore, removal of braces should be considered in cases whereby these sequences are vital (eg, acute stroke).

PATIENT PREPARATION

Patients older than 6 years are usually able to cooperate with MR imaging after an explanation of the procedure and reassurance. Distraction techniques including the use of MR imaging–compatible music and video players as well as scanning during off hours to minimize ambient noise and activity can also be helpful. Similarly, newborns and young infants may tolerate MR imaging without the need for sedation, if they are well fed and comfortably swaddled. For young children less than 6 years of age, conscious or deep sedation may be required to relieve patient anxiety and minimize patient motion during imaging.

Sedation

Several sedation medications are currently used for pediatric MR imaging, including chloral hydrate, pentobarbital, propofol, and midazolam.[6,7] Advantages of sedation in children who cannot tolerate MR imaging while awake include reduction in scan time and improvement in image quality. Generally, the least amount of sedation necessary for patients to tolerate MR imaging is administered, both to minimize post-MR imaging side effects and to facilitate patient induction and emergence from sedation. As always, the proper balance should be maintained between adequate sedation for patient comfort and scan performance and minimization of potential neurologic and cognitive effects associated with prolonged anesthesia.[8]

Intravenous Contrast Administration

Contrast agents used for clinical pediatric MR imaging are gadolinium chelated, extracellular contrast agents that cause T1 shortening within blood vessels and perfused tissues. The typical dose for intravenous administration is 0.1 mmol/kg.[9]

IMAGING SEQUENCES

Brain

A minimal MR imaging examination of the brain (termed *brain screen* at the authors' institution) includes sagittal T1, axial T2 fluid-attenuated inversion recovery (FLAIR), axial T2 fast spin echo, coronal T2, and axial DWI. Additional sequences are obtained based on the clinical indication (**Table 1**). When the clinical question is limited to change in ventricle size for chronically shunted patients, SSFSE imaging is adequate for this evaluation, requires only a few minutes of scanner time, and can typically be performed without sedation in the authors' experience (**Fig. 1**).

Spine

The MR imaging sequences for the evaluation of pediatric spine emergencies also depend on the