Abstract:
Pediatric appendicitis is one of the most common emergencies presenting in the emergency department. Ultrasonography is a reliable, cost-efficient, and reproducible imaging choice; however, it is highly dependent upon sonographer expertise, body habitus, and underlying bowel gas. When considering imaging using the ALARA (as low as reasonably achievable) principle and the increased availability of magnetic resonance imaging (MRI), the focus has shifted to using MRI as an alternative to computed tomography to diagnose pediatric appendicitis. There are a growing number of studies, highlighting the use of MRI for diagnosing pediatric appendicitis. This article will provide an overview of MRI technique and a discussion of the available literature on the utility of MRI in the diagnosis of appendicitis.

Keywords:
appendicitis; abdominal pain; children; magnetic resonance imaging; ultrasonography

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Magnetic Resonance Imaging in the Evaluation of Acute Appendicitis

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In the United States, pediatric patients often present to the emergency department complaining of abdominal pain. In fact, when a child presents with acute abdominal pain, acute appendicitis is one of the most common indications for surgery.[1,2] The diagnosis of appendicitis may pose a challenge, especially in patients who present with atypical symptoms.[2,3] Current imaging algorithms revolve around obtaining a definitive diagnosis with ultrasonography (US) and/or computed tomography (CT). The choice of imaging modality is institution specific and varies depending on access and available sonographer expertise. Computed tomography has gained wide acceptance in the evaluation of appendicitis because of its high accuracy, availability, and rapidity as well as operator independence.[4,5] With growing evidence and concern for radiation-induced cancers in children, there has been an even greater emphasis on the use of US in the emergency setting.[6,7] However, US has inherent limitations in patients with a larger body habitus and excessive underlying bowel gas, and above all, it is extremely operator dependent.

Magnetic resonance imaging (MRI) has emerged as an attractive and viable option in the diagnosis of appendicitis in the emergency department setting. It also provides a comprehensive evaluation of the abdomen and pelvis, which is invaluable in cases where the appendix is proven not to be the etiology of the patient's symptoms.[8] Unenhanced MRI has recently been investigated as an imaging

technique for diagnosing acute appendicitis in children and has demonstrated promising results,[9,10] although applying MRI protocols to children is limited due to examination length, availability of technology, need for sedation, and cost. The added use of intravenously administered gadolinium contrast during MRI performed for the evaluation of acute abdominal pain is debatable. However, it has recently been shown to provide improved visualization of the appendix and increase the accuracy for diagnosing alternative pathologies.[8,11]

IMAGING TECHNIQUE

There are various considerations in performing an MRI on a pediatric patient, most important of which is the length of the examination. A reduced scan time can decrease the need for sedation and increase patient throughput. The disadvantages of subjecting a pediatric patient to anesthesia are well documented in the medical literature;[12-14] therefore, every effort should be made to perform an MRI without sedation. Recent advances in scanner technology and sequences now allow for a thorough evaluation of the abdomen and pelvis with a fewer number of sequences, performed in a free breathing fashion. These examinations are performed using breath-hold technique in older children (>6 years of age at least) and with respiratory triggering in younger children.[14,15] Although most of these examinations can be performed rapidly, with a limited number of sequences, sometimes motion-related artifacts cannot be entirely eliminated. Claustrophobia can complicate the performance of MRI, but the use of MRI video goggles can help alleviate some of the anxiety related to this.

These examinations can be performed on a 1.5 or 3.0 Tesla system (magnet field strength), depending on availability; however, the higher magnet strength produces a more robust signal. Among institutions that are performing MRI examinations on this subgroup of patients, the popular sequences will include axial and coronal single-shot turbo spin-echo (SS TSE), with and without fat saturation technique as well as axial/coronal diffusion-weighted imaging (DWI). Fat saturation is usually done by adding an inversion recovery pulse to the sequence, and this technique will help visualize inflammatory changes within the abdomen. Some groups also advocate adding a gradient recalled echo T1-weighted image, to shorten the examination time. The slice thickness varies between 3 and 4 mm, depending on the age of the child and field of view chosen. The images are generated when a phased-array (surface) coil is placed on the patient, when inside the magnet. This also allows parallel imaging to be used with most sequences, which will accelerate the sequences to further shorten the examination time. Surface coils also yield a higher signal to noise ratio, thereby improving overall image quality.[16]

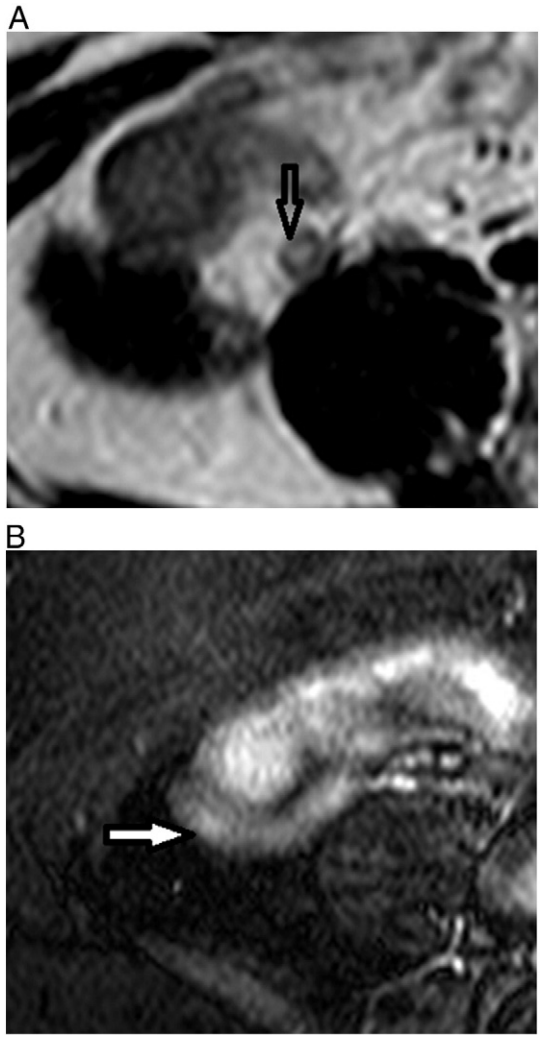

Figure 1. A, 16-year-old adolescent girl with lower abdominal pain. Axial T2 SS-FSE sequence demonstrating a collapsed, tubular structure in the right lower quadrant (arrow), adjacent to the cecum. B, 12-year-old boy with abdominal pain. Axial fat-saturated T2W sequence showing a linear, tubular, blind-ending structure posterior to the cecum representing the normal appendix (arrow). Note that there is no fluid or fat stranding around the appendix to suggest periappendiceal inflammation.

The use of intravenous magnetic resonance contrast material (gadolinium based) is debatable and depends on the radiologist's preference. Some argue that it is helpful when alternate etiologies are suspected as the etiology of the abdominal pain. In our experience, we have not found any value to