The Role of MRI in the Diagnosis of Acute Appendicitis in Pediatric Patients and Pregnant Women

- While CT is the traditional gold standard imaging modality for diagnosing acute appendicitis, its use in pregnant and pediatric patients is discouraged due to radiation exposure.
- Ultrasound is the recommended first imaging modality for suspected appendicitis in pregnant and pediatric patients.
- Ultrasound is limited in pregnant patients because of difficulties in visualizing the appendix due to anatomical changes.
- Non-contrast MRI is an accurate method for diagnosing appendicitis and is recommended for pregnant and pediatric patients with a non-diagnostic ultrasound.
- Use of MRI for the diagnosis of appendicitis in pregnant patients shortens the length of stay and does not increase the cost of care.

For many years, CT imaging has been considered the diagnostic method of choice for patients with suspected appendicitis, thanks to its high speed and high diagnostic accuracy. However, it is well established that the developing fetus is very susceptible to radiation. Moreover, recent studies have indicated an increased risk of radiation-induced malignancy in children who have undergone only one CT examination. For this reason, ultrasound and MRI have become established as preferable imaging methods for the diagnosis of appendicitis and other conditions that cause abdominal pain in children and pregnant women.

Figure 1. Normal Appendix. Coronal (A) and sagittal (B) T2-weighted MRI images demonstrate a normal appendix (yellow arrows) in a pregnant patient.

Pregnant Patients
Acute appendicitis is the most common non-obstetric indication for surgery in pregnant women, but it can be challenging to diagnose in part because symptoms such as nausea, vomiting, and abdominal pain are common during pregnancy. An ultrasound examination is recommended as the first imaging examination for pregnant patients with suspected appendicitis. Ultrasound has the advantage of being rapid, relatively inexpensive, and
readily available. However, because of the changes in anatomy that occur during pregnancy, equivocal or non-diagnostic ultrasound scans are frequent and have been reported in the literature to be in the range of 68–97%. However, the specificity of ultrasound for the diagnosis of appendicitis in pregnant patients is reported to be 99%.

When ultrasound is non-diagnostic, a non-contrast MRI is recommended (Figures 1 and 2). MRI is generally regarded as safe for pregnant patients, and contrast material, which has the potential to be harmful, is not used to detect appendicitis. In the past few years, several studies on the accuracy of MRI for the diagnosis of appendicitis have been published. These studies have demonstrated that MRI has a sensitivity in the range of 80–100%, a specificity of 94–100%, a positive predictive value (PPV) of 57–69%, and a negative predictive value (NPV) of 99–100%. These results indicate that MRI has similar accuracy to CT for the diagnosis of appendicitis. MRI may also provide an alternate diagnosis for the cause of abdominal pain, such as colitis (Figure 3), pyelonephritis, hydronephrosis, diverticulitis, or cholelithiasis.

In some cases, the appendix may not be visualized by MRI because of problems such as motion artifacts due to fetal movement or to breath-hold problems. In such cases, CT imaging may be considered.

**Pediatric Patients**

Because children are smaller than adults and generally have less body fat, ultrasound is much more effective for the diagnosis of appendicitis than for adults. A meta-analysis of 26 studies in children showed that the pooled sensitivity of ultrasound was 88% (95% CI, 86%, 90%), with a specificity of 94% (95% CI, 92%, 95%). Therefore, ultrasound may be the only imaging examination needed for many children with suspected appendicitis.

If an ultrasound examination is equivocal or the appendix cannot be visualized in children with suspected appendicitis, non-contrast MRI offers an alternative to CT that does not result in radiation exposure. In one recent study, MRI was shown to have a sensitivity of 93% (95% CI, 78%, 99%), a specificity of 98% (95% CI, 90%, 100%), a PPV of 96.5%, and an NPV of 96.2%. Therefore, MRI has a similar performance to ultrasound in the pediatric population.
The principal limitation of MRI is that the patient must remain still during the examination. Children under the age of six years are generally not able to cooperate during the MRI examination and need to be anesthetized. Therefore, if further imaging is necessary, CT may be necessary for a prompt diagnosis.

**Clinical Outcomes**
In a recent retrospective review of pregnant patients seen with abdominal pain and suspected appendicitis at a tertiary referral center, the use of MRI as opposed to other diagnostic techniques did not affect clinical outcomes and allowed safe discharge from the hospital. Patients in the MRI group were more frequently discharged directly from the emergency department and had shorter length of stays in the hospital. Seven of the 48 patients in the non-MRI group underwent exploratory surgery compared to one of the 31 patients in the MRI group. The mean hospital charges were similar in both those who did and did not receive MRI.

**Scheduling**
MRI (as well as ultrasound and CT) is available 24 hours a day in the emergency room for the evaluation of acute appendicitis. MRI for suspected acute appendicitis requires consultation with an ER radiologist.

**Further Information**
For further information on imaging for suspected appendicitis in children and pregnant patients, please contact Anand Prabhakar, MD, Division of Emergency Imaging, Department of Radiology, Massachusetts General Hospital, at 617-726-3051.

We would like to thank Geoffrey Rutledge, MD, and Anand Prabhakar, MD, Department of Radiology, and Matthew Hutter, MD, Department of Surgery, Massachusetts General Hospital, for their assistance and advice on this issue.

**References**
Aspelund G, et al. (2014). *Ultrasonography/MRI versus CT for diagnosing appendicitis.* Pediatrics **133:**586-93

Moore MM, et al. (2014). *MRI for clinically suspected pediatric appendicitis: case interpretation.* Pediatric radiology **44:**605-12


Rosines LA, et al. (2014). *Value of gadolinium-enhanced MRI in detection of acute appendicitis in children and adolescents.* AJR. American journal of roentgenology **203:**W543-8

Theilen LH, et al. (2015). *Utility of magnetic resonance imaging for suspected appendicitis in pregnant women.* Am J Obstet Gynecol **212:**345 e1-6

©2015 MGH Department of Radiology

Janet Cochrane Miller, D. Phil., Author
Raul N. Uppot, M.D., Editor