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What to Expect When They are Expecting: Magnetic Resonance Imaging of the Acute Abdomen and Pelvis in Pregnancy

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In this article, we discuss the challenges in the diagnosis of acute abdominopelvic pain in pregnant patients, role of imaging, and advantages of MRI over other modalities. Methods consist of pictorial review. We review the differential diagnoses and illustrate the MRI findings in pregnant patients with acute abdominopelvic pain, including gastrointestinal, gynecologic, urologic, and vascular etiologies.

Introduction

Accurate clinical diagnosis of abdominopelvic pain in pregnancy can be challenging owing to a variety of factors. It is confounded by variations in normal anatomy and physiology that occur to accommodate the requirements of the placenta and fetus. Physiologic leukocytosis during pregnancy, for example, can make clinical diagnosis of infectious processes difficult. The total leukocyte count in the second trimester can reach 16,900 cells/μL in the absence of infection.[1] Additionally, the displacement of normal anatomical structures by the gravid uterus may alter typically classic clinical symptoms in the diagnosis of acute pain in nonpregnant women. For instance, up to 25% of pregnant patients with acute appendicitis do not experience right lower quadrant pain.[2]

Diagnostic imaging is crucial when the clinical history and physical examination findings are ambiguous. Established diagnostic modalities that use ionizing radiation, including radiography and computed tomography (CT), should be avoided in pregnant patients owing to risks to the fetus. Ultrasound is frequently the first-line imaging modality because of its wide availability and lack of ionizing radiation.[3] The limitations of ultrasound become most evident during later stages of pregnancy when the normal anatomy of abdominal and pelvic organs is distorted and displaced by the gravid uterus. The advantages of magnetic resonance imaging (MRI) include its wide field of view, high soft tissue contrast, and lack of ionizing radiation.

MRI is particularly useful to guide urgent surgical interventions, especially in cases of acute appendicitis, ovarian torsion, uterine rupture, and small bowel obstruction (SBO). Common nonsurgical causes of pain requiring timely diagnosis include inflammatory bowel disease, biliary disease, degenerating fibroids, adnexal masses, urinary tract obstruction or infection or both, and venous thromboembolic disease. The aim of this review is to describe differential diagnoses and MRI findings in pregnant patients with acute abdominopelvic pain, including gastrointestinal, gynecologic, urologic, and vascular etiologies (Table). The discussion of obstetric causes of acute pain is beyond the scope of this review, with the exception of acute uterine rupture that clinically may simulate acute appendicitis.

General Considerations

The American College of Radiology (ACR) approves the use MRI in pregnant patients during any trimester. To date, no study has demonstrated deleterious effects of MRI on the developing fetus.[4] Specifically, MR imaging at 1.5 T has been shown to have no adverse effects on neonatal hearing function or birth weight percentile.[5] Gadolinium-based contrast agents should only be used in pregnant patients when their usage is considered critical to establishing a diagnosis, and the benefits outweigh the unknown risk to the fetus.[6] The radiofrequency energy used in MRI is nonionizing, but it does deposit energy in the form of heat. Although the temperature rises associated with MRI are below the expected teratogenic levels, specific absorption rate and tissue heating should be taken into consideration when determining which pulse sequences to use to image pregnant patients.[7]

At our institution, imaging of pregnant patients is performed using a 1.5-T magnetic resonance (MR) imaging system. All examinations are performed without the use of oral contrast media. When possible, the examinations are monitored by a radiologist and imaging parameters are adjusted in real time. Patients are imaged in the supine position with a surface-phased

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Table
Discussed Causes of Acute Abdominopelvic Pain in Pregnancy

Gastrointestinal
Acute appendicitis
Inflammatory bowel disease
Small bowel obstruction
Hepatobiliary
Cholelithiasis
Acute cholecystitis
Acute pancreatitis
HELLP syndrome
Urologic
Renal obstruction
Urinary tract infection
Pyelonephritis
Gynecologic
Adnexal masses
Ovarian torsion
Endometrioma
Uterine rupture
Vascular
Gonadal vein thrombosis

array coil covering the abdomen and pelvis. The field of view extends from the pubic symphysis to the dome of the liver. When symptoms are localized to the pelvis, the superior extent of the field of view is lowered to the inferior margin of the liver. The imaging protocol for most examinations that include axial, sagittal, and coronal T2-weighted single-shot fast spin echo (SSFSE) sequences; axial T2-weighted SSFSE with fat saturation; axial in-phase and out-of-phase T1-weighted gradient echo sequence; and axial diffusion–weighted imaging. The T2-weighted SSFSE images allow for evaluation of the bowel with minimal motion artifacts. These also allow for identification of the appendix and other pathology in multiple imaging planes. The axial T1-weighted gradient echo images can help determine patency of the appendix, if susceptibility artifact from intraluminal air can be demonstrated. The fat saturated T2-weighted images are used to accentuate edema or fluid that can be seen in appendicitis. Inversion recovery sequences may also be used for this purpose.

Gastrointestinal

Acute Appendicitis

Acute appendicitis is the most common cause of acute abdominopelvic pain during pregnancy, complicating approximately 1 in 1500 pregnancies.[8] It is also the most common nonobstetric indication for emergency surgery in pregnant patients. The clinical diagnosis of acute appendicitis can be confounded by alterations in the normal physiology and anatomy in pregnancy, particularly as the pregnancy progresses. These alterations include physiologic leukocytosis and displacement of the inflamed appendix by the gravid uterus away from the abdominal wall and away from the right lower quadrant. When the clinical presentation is not classic, imaging is indicated to reduce delays in surgical intervention.

According to the ACR Appropriateness Criteria, ultrasound with graded compression is the first-line imaging choice in pregnant patients with suspected appendicitis.[9] The appendix, however, may not be identified in up to 88% of pregnant patients evaluated with ultrasound.[10] MRI is recommended in cases after negative or equivocal ultrasound. CT is not routinely used owing to the risks of ionizing radiation to the developing fetus.

One of the major benefits of MRI is its 100% negative predictive value for the evaluation of appendicitis in pregnancy.[11] A normal appendix on MRI is a blind-ending tubular structure with a diameter

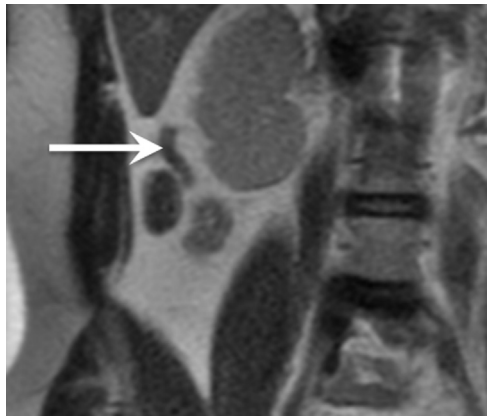

Fig. 1. Normal appendix. Coronal T1 image depicts a normal appendix (arrow), measuring less than 6 mm in diameter, with a wall thickness of less than 2 mm. There is no periappendiceal edema.

less than or equal to 6 mm and lack surrounding edema (Fig 1). The signal intensity of the wall is similar to muscle on T1- and T2-weighted images. In patients with acute appendicitis (Fig 2), MRI depicts localized inflammation in the right lower quadrant, surrounding a dilated ($\geq$7 mm), thick-walled appendix.[11] MRI may also allow for diagnosis of complications, including rupture and abscess formation.

Inflammatory Bowel Disease

Inflammatory bowel disease (IBD), including Crohn's disease and ulcerative colitis, commonly affect women in the reproductive aged population, with a peak incidence between 15 and 25 years.[12] Clinical symptoms of IBD in pregnant patients are often nonspecific, consisting of nonlocalized abdominopelvic pain, fever, nausea, vomiting, and diarrhea. Terminal ileum involvement is common, and may mimic acute appendicitis, particularly in pregnant patients without a prior diagnosis of IBD.

Both CT and MR enterography are used to diagnose and monitor disease activity and complications in patients with IBD. In pregnant patients with fever and nonlocalized abdominopelvic pain, ultrasound and MRI are the initial imaging modalities of choice, owing to the lack of ionizing radiation.[13]

The MRI findings in pregnant patients with IBD are akin to those in nonpregnant patients. Mural findings include wall thickening of $\geq$3 mm, mucosal ulcerations, wall edema, luminal stenosis, and prestenotic dilatation.[14] Mesenteric findings include vascular congestion (comb sign), fibrofatty proliferation (creeping fat), and lymphadenopathy.[14] Abscesses and fistulae are also detectable by MRI (Fig 3). Findings classically used to determine disease activity are bowel wall thickness, T1 stratification, abscess formation, and contrast enhancement.[15]

Small Bowel Obstruction

SBO is an unusual but potentially catastrophic occurrence during pregnancy, and carries a risk of fetal loss.[16] The most common symptoms are nonspecific and include abdominopelvic pain, vomiting, and obstipation.[16] Adhesions are the most common cause of obstruction, with other less common causes including hernia, malignancy, volvulus, or intussusception.[17]

Abdominal radiographs are often the first imaging study performed in patients with suspected SBO. Although radiography may detect evidence of obstruction, it is limited in determining the site or cause of obstruction. MRI is useful in both detecting and characterizing SBO, and has greatest use in patients for whom