Imaging of the acute abdominal pain in Pregnancy: Spectrum of diagnostic patterns, sites involved and proposal for a new management scheme.

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Learning objectives

- Describe the pathological processes source of abdominal pain during pregnancy and show the characteristic imaging findings
- Discuss the risks to the fetus from diagnostic imaging modalities and contrast agents
- Propose recommendations for emergency diagnostic imaging of pregnant patients

Background

Introduction

Acute abdominal pain in pregnant patients presents a difficult diagnostic challenge. The differential diagnosis during pregnancy is extensive in that the abdominal pain may be obstetric in nature or may be caused by disease of other intraabdominal or intrapelvic structures. Because of the anatomic and physiologic changes that occur with pregnancy, localization of disease can be difficult. Fig. 12 on page 8

Anatomy of the Pregnant Patient

In early pregnancy, the uterus maintains its normal version and flexion, which is usually anterior and is best illustrated on sagittal images. The bladder lies immediately anterior and inferior to the uterus. The vagina is posterior to the bladder and urethra and anterior to the rectum and anus. The ovaries lie within the pelvis lateral to the midline uterus and are suspended by the mesovarium, broad ligaments, and suspensory infundibulopelvic ligaments. The ovaries are easily recognized because of the high signal intensity of the follicles.

During the second and third trimesters of pregnancy, the gravid uterus increases in size and displaces the pelvic contents from their normal locations. The adnexal structures are displaced superiorly and laterally. The appendix is often superiorly displaced from its normal position in the right lower quadrant, often up to the level of the liver.
The diagnosis is based on the clinical history, physical examination, and laboratory analysis. Imaging examinations are often necessary to confirm the diagnosis and contribute to the survival of the patient because the single greatest cause of increased morbidity in the pregnant patient with an acute abdomen is delay in diagnosis.

**Diagnostic imaging**

**CT**

The use of CT is well established in the evaluation of acute abdominal pain. CT provides excellent anatomic detail, but a considerable dose of ionizing radiation is conferred to the fetus, making this technique undesirable.

**Sonography**

Sonography is a safe, versatile imaging technique to use in pregnant patients and is often the first imaging technique used in a pregnant patient with abdominal pain. However, in the presence of a gravid uterus, intraabdominal organs may be displaced and challenging to visualize on sonography also it can be limited in patients with large body habitus or in the presence of extensive air or calcification, finally it is very dependent on operator experience. **Fig. 1 on page 5**

**MR**

MRI provides a good overall topographic display and high intrinsic soft-tissue contrast.

MRI also benefits from lack of ionizing radiation, making it safe to use in pregnant patients. Although a number of prior reports have shown the ability of MRI to evaluate the fetus using current short-duration sequences, there are fewer reports describing the investigation of maternal abdominal and pelvic disease on MRI. **Fig. 2 on page 6** **Fig. 3 on page 7**

**Safety**

**Sonography**
Up to now there is no evidence of fetal adverse effects related with the US technique too (as well), even though is encouraged use of Doppler reducing times and lowering the acoustic output as far as possible.

**MR**

To our knowledge, no study has demonstrated deterious effects on the fetus secondary to MR imaging, although the most experience we count on today is related with studies relacionated with MR of magnetic field intensity no superior than 1,5 T. In general we don’t recommend the use of equipment with magnetic fields of 2’5 T or greater because experience is less.

Even though there is no evidence of fetal risk, some international organizations recommend being cautious in the first trimester of pregnancy.

There has been on-going concern that acoustic noise associated with MR may impact the fetus. Reeves et al. (2010) conducted an investigation to establish whether fetal exposure to the operating noise of 1.5-T MR imaging causes cochlear injury and subsequent hearing loss in neonates. The findings in this study provide some evidence that exposure of the fetus to 1.5-T MR imaging during the second and third trimesters is not associated with an increased risk of substantial neonatal hearing impairment.

Also the ACR does not recommend the administration of gadolinium contrast material to pregnant women, as gadolinium-based contrast agents have been shown to cross the placental barrier.

**Images for this section:**
Transverse US Gray-scale image of a second trimester fetus.

Fig. 1: US
Coronal STIR, Axial T1 SE and Sagittal T2 SSFSE BH Asset images show dilatation of the lateral ventricles in a fetus of 25 weeks gestation because of an intrauterine Toxoplasmosis.

**Fig. 2: MR**
Normal appearance of the pregnant pelvis at 24 weeks gestation. Sagittal and coronal T2-weighted SSFSE images.

Fig. 3: MR
<table>
<thead>
<tr>
<th>Organ System</th>
<th>Cause</th>
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<tbody>
<tr>
<td>Obstetric</td>
<td>Abortion</td>
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<td>Ectopic pregnancy</td>
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<td>Preterm labor</td>
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<td>Placental abruption</td>
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<td>Uterine rupture</td>
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<td>Gynecologic</td>
<td>Adnexal mass or ovarian cyst</td>
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<td>Adnexal torsion</td>
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<td>Uterine leiomyoma</td>
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<td>Endometriosis</td>
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<td>Pelvic inflammatory disease</td>
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<td>Gastrointestinal</td>
<td>Appendicitis</td>
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<td>Inflammatory bowel disease</td>
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<td>Intestinal obstruction</td>
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<td>Gastroesophageal reflux</td>
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<td>Peptic ulcer disease</td>
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<td>Hepatobiliary</td>
<td>HELLP syndrome</td>
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<td>Acute fatty liver of pregnancy</td>
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<td>Cholelithiasis or choledocholithiasis</td>
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<td>Acute cholecystitis</td>
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<td>Acute pancreatitis</td>
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<td>Hepatitis</td>
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<td>Hydrenephrosis of pregnancy</td>
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<td>Urolithiasis</td>
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<td>Pyelonephritis</td>
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<td>Cystitis</td>
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<td>Vascular</td>
<td>Gonadal vein thrombosis</td>
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<td></td>
<td>Mesenteric vein thrombosis</td>
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</table>

**TABLE 1**: Causes of Abdominal Pain in Pregnant Women by Organ System

**Fig. 12**: TABLE 1
Imaging findings OR Procedure details

Technique

**MR-** MR examinations of the abdomen and pelvis were performed on a 1.5-T system (Signa EXCITE 11.0, General Electrics).

All MR examinations were performed using a set protocol including unenhanced T1-weighted images, acquired as a breath-hold spoiled gradient echo sequence (TR range/TE range, 120-170/4.0-4.5; flip angle, 80-90°) axial in-phase and out-of-phase T1-weighted GRE sequences, and coronal T2-weighted SSFSE sequences; axial true fast imaging with steady-state precession (FISP) sequences; T2-weighted images (TR/effective TE, infinite/90; 2-3 acquisitions).

Section thickness was 7-10 mm, and the matrix size was 128-192 × 256 (phase × frequency encoding) for all sequences.

**Sonography**- Philips iU22 xMATRIX ultrasound system and Toshiba apio 500 ultrasound system.

Pathological findings

**Nonobstetrical causes**

**Apendicitis**

Acute appendicitis is the most common surgical emergency in pregnancy, the incidence in pregnant women (0.05-0.07%) is similar to that in the general population. The diagnosis can be difficult because these patients rarely present with classic symptoms such as anorexia, fever, nausea, vomiting and periumbilical pain localizing to the right lower abdominal quadrant and are more likely to present with perforation because diagnosis tends to be delayed.

**Sonography**- Ultrasound with graded compression has long been considered the initial preferred imaging technique for suspected appendicitis in pregnant women because it is safe (i.e., does not involve ionizing radiation) and inexpensive. The examination is routinely performed immediately after clinical suspicion for acute appendicitis is raised.
Ultrasound imaging for the diagnosis of acute appendicitis involves graded compression along the border of the cecum to assess the compressibility of the appendix. Imaging features suggestive of acute appendicitis on ultrasound include a noncompressible tubular blind structure measuring greater than 6 mm in thickness at point of maximal tenderness, with or without the presence of surrounding inflammation. Fig. 4 on page 14

However, ultrasound evaluation of the appendix is challenging in cases where the appendix is not visualized and the study is considered indeterminate for the diagnosis of acute appendicitis.

In a nonobstetric population, some studies have shown that graded compression sonography and unenhanced helical CT had similar accuracy for the diagnosis of acute appendicitis. In pregnant women, ultrasound has been shown to be accurate and useful in the first and second trimesters but technically difficult in the third trimester because of the large size of the gravid uterus Fig. 5 on page 14. Variable anatomic location of the normal appendix (i.e., retrocecal, pelvic, or left lower quadrant) combined with variable anatomic displacement of the appendix by the gravid uterus both can contribute to the difficulty in sonographic visualization.

Overall, there has been variable success with ultrasound in visualizing the appendix and in making the diagnosis of acute appendicitis, which may be attributable to the great interuser variability of the ultrasound technique. Fig. 6 on page 15

**MR** - MR imaging features of a normal appendix include a diameter less than 6 mm, an appendiceal wall thickness less than 2 mm, low luminal signal intensity on T1- and T2-weighted images, and no periappendiceal fat stranding or fluid.

MR imaging features of appendicitis include an appendiceal diameter greater than 7 mm, an appendiceal wall thickness greater than 2 mm, highsignal-intensity luminal contents on T2-weighted images due to fluid or edema, and hyperintense periappendiceal fat stranding and fluid. MR imaging has been described as an effective modality for diagnosis of appendicitis during pregnancy, with 100% sensitivity and 94% specificity reported.

**Small Bowel Obstruction and Ileus**

Small bowel obstruction or ileus can manifest as generalized vague abdominal pain often accompanied by nausea and vomiting and can occur in pregnant patients, especially those with a history of abdominal surgery. Both conditions manifest as dilated, fluid-filled bowel loops at MR imaging or sonography Fig. 7 on page 16. A transition point and
even a possible cause of a small bowel obstruction can also be readily identified with MR imaging.

**Physiologic hydronephrosis**

Physiologic dilatation of the renal collecting system is a common phenomenon during pregnancy, reportedly occurring in up to 90% of pregnant patients. Although physiologic hydronephrosis is usually asymptomatic, it can manifest as abdominal pain. Physiologic dilatation of the renal pelvis and ureter is due to a combination of hormone-related relaxation of the ureters during pregnancy and extrinsic compression of the ureters by the growing uterus and engorged ovarian veins against the iliopsoas muscle. Physiologic dilatation of the collecting system and ureter occurs predominantly on the right side in 80%-90% of patients.

**Obstructive Hydronephrosis**

As in nonpregnant patients, obstructive hydronephrosis in pregnant patients is most commonly due to urinary tract calculi. It typically manifests in the second or third trimester with equal involvement of the right and left sides.

Potential complications of urolithiasis include pyelonephritis and premature labor induced by renal colic with or without concomitant infection. Therefore, the ability to detect and differentiate physiologic versus obstructive hydronephrosis is important for patient care.

Ultrasonography (US) is usually the primary imaging modality for evaluation of hydronephrosis and urolithiasis during pregnancy Fig. 8 on page 17. However, MR imaging can also readily demonstrate dilatation of the collecting systems and ureters without use of ionizing radiation.

An abdominal MR imaging protocol for abdominal pain in pregnant patients that includes T2-weighted images extending superiorly through the kidneys has high sensitivity for detection of urinary tract dilatation and identification of the site of obstruction Fig. 9 on page 18.

Features of obstructive hydronephrosis at MR imaging include renal enlargement, perinephric fluid, and an abrupt change in ureteral caliber above or below the uterus. When visible at MR imaging, the obstructing ureteral calculus appears as a low-signal-intensity filling defect in the ureter. In contrast, physiologic hydronephrosis at MR imaging is characterized by gradual, smooth tapering of the mid to distal ureter due to extrinsic compression between the gravid uterus and iliopsoas muscle. There is usually no associated renal enlargement or perinephric fluid.

However, MR imaging has not become a first-line imaging examination
for suspected hydronephrosis in pregnancy largely due to the limited detection of small calculi and limited characterization of the exact size and shape of calculi.

**Obstetrical causes**

Common obstetrical causes of pain during pregnancy include complications related to adnexal masses, ovarian torsion, and leiomyomas. Adnexal masses are often first detected at the time of a routine first trimester dating or second trimester anatomic survey ultrasound examination. Ovarian torsion and leiomyoma degeneration both have a higher incidence during pregnancy.

**Adnexal Mass**

Adnexal masses occur in approximately 2% of all pregnancies. Adnexal masses are not a usual cause of pain, with 65% of these masses being asymptomatic and discovered incidentally on physical examination or sonography with all they may cause pain if they rupture, rapidly enlarge, or serve as a lead point for torsion.

Imaging evaluation of the adnexa should be performed, starting with ultrasound Fig. 11 on page 20, in all pregnant women presenting with pain. Ultrasound provides the ability to distinguish adnexal masses that are small, uncomplicated, and likely to spontaneously resolve from those that appear larger and more complex with a higher likelihood of malignancy, torsion, or persistent pain from mass effect during pregnancy.

The most common adnexal masses during pregnancy are corpus luteum or other functional ovarian cysts. The differential diagnosis for a complex-appearing adnexal mass includes hemorrhagic corpus luteum cyst, ovarian cystadenoma, and ovarian teratoma. However, approximately 1-8% of adnexal masses found during pregnancy are malignant. Therefore, when the sonographic appearance of an adnexal mass is not specific, MRI can be used for further characterization to help determine patient management during pregnancy. Complex adnexal masses, particularly if they are already a source of pain, may warrant surgical removal during pregnancy because of an increased risk of torsion, rupture, and malignancy. MR imaging allows differentiation of extraovarian masses such as an exophytic fibroid or ectopic pregnancy from an actual ovarian mass.

The most common ovarian neoplasm found in pregnancy is the benign cystic teratoma Fig. 10 on page 19, which arises from ovarian germ cells. At MR imaging, these
lesions have high signal intensity on T1-weighted images and intermediate signal intensity on T2-weighted images owing to the high-lipid-content cyst fluid. The fat in these lesions can be further verified on MR images by using frequency-selective fat saturation Fig. 13 on page 21.

Images for this section:

Appendicitis in a 30 y.o. pregnant woman. Sonography shows a dilated appendix (10 mm) with periappendiceal fluid.

Fig. 4: US
Appendicitis in a 33 y.o. pregnant woman seen with sonography

Fig. 5: US
<table>
<thead>
<tr>
<th>Imaging Technique</th>
<th>Major Advantages</th>
<th>Major Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>Cost and accessibility; safety profile</td>
<td>Limited assessment of alternative diagnoses; limited by body habitus; operator dependent; high rate of nonvisualized appendix</td>
</tr>
<tr>
<td>CT</td>
<td>High sensitivity and specificity; accessibility; ability to identify alternative diagnoses</td>
<td>Ionizing radiation</td>
</tr>
<tr>
<td>MRI</td>
<td>High sensitivity and specificity; ability to identify alternative diagnoses</td>
<td>Cost and accessibility; robust imaging technique required for good results; relatively long examination times</td>
</tr>
</tbody>
</table>

**TABLE 2:** Summary of Imaging Techniques

**Fig. 6:** TABLE 2
Fig. 7: US and X-RAY

X-ray abdominal image shows a 35 weeks pregnant woman. Same patient transverse gray-scale US images of left abdomen show dilated loop of bowel because of an internal bride.
Hydronephrosis in a 32 weeks pregnant woman. Sonography show an ureteropelvic dilatation of the right kidney with a minimal tab of fluid compatible with urinoma.

Fig. 8: US
Fig. 9: MR

Hydronephrosis in a 32 weeks pregnant woman. Sagittal and coronal T2-weighted SSFSE images show an uretero pyelic dilatation of the right kidney.
A 32 y.o. pregnant woman with an adnexal mass viewed first by sonography. Transverse gray-scale US image of right abdomen shows an hyperecogenic mass.

MR: T2-weighted image confirms the diagnostic, shows an adnexal mass in the right lower quadrant compatible with Teratoma.

**Fig. 10:** MR and US
Teratoma in a 22 weeks pregnant woman. US transversal image shows a fluid-fat content mass in the right low quadrant.

Axial Dualecho FSPGR BH Asset MR image confirms the mass in the right lower quadrant.

**Fig. 11:** US and MR
Same patient as in figure 10. Axial T1 FSPGR, Axial 2D FIESTA FATSAT and Coronal T2 SSFSE BH ASSET MR images show an adnexal mass in the right lower quadrant compatible with teratoma.

**Fig. 13: MR**
Conclusion

Abdominal pain in pregnant women can be difficult to diagnose, secondary to multiple confounding factors found in normal pregnancy. The Diagnostic approach is based on abdominal examination, laboratory test and imaging techniques. Sonography is performed as a first, safe and accurate method. MR imaging also allows evaluation of additional structures that may be the true source of abdominal pain in the pregnant patient. We must know the spectrum of radiologic manifestations to help us to manage these patients properly.

References


Personal Information