MRI of the acute abdomen in pregnancy

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A 24 year old woman who is 8 weeks pregnant presents with nonfebrile acute pelvic pain. An enhanced MRI shows a crenulated thick-walled briskly enhancing 2 cm cyst in the left ovary and a separate low T2 and high T1 signal 10 cm solid left para-uterine mass. Which is TRUE:

A. Tubo-ovarian abscess is the leading diagnosis
B. The use of gadolinium was appropriate
C. Red degeneration of a fibroid is the leading diagnosis
D. The ovarian finding merits serial ultrasound follow-up
E. The pregnancy should be terminated
Learning objectives

- Describe the rationale, risks, and technique, for imaging the acute abdomen in pregnancy with MRI

- Recognize common causes of acute abdominal pain in pregnancy seen at MRI

- Knowledge gap addressed: Limited knowledge and experience among radiologists in using MRI to evaluate acute abdominal pain in pregnancy
Early pregnancy

5 WEEK GESTATION - ARF DUE TO OBSTRUCTION BY THECA LUTEIN CYSTS

5 WEEK GESTATION (UNKNOWN) – CT FOR STAGING BLADDER MASS

10 WEEK GESTATION – MRI FOR STAGING CERVICAL CANCER
Why image the acute abdomen?

- Sudden severe abdominal pain needing urgent medical or surgical attention

- Early CT vs standard treatment (n = 118):
  - Prospective randomized study (Addenbrooke’s)
  - Excluded those needing immediate surgery or CT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Early CT (n = 55)</th>
<th>Standard care (n = 63)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>0 (0%)</td>
<td>7 (11%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Serious diagnosis missed at 24 hrs</td>
<td>2 (4%)</td>
<td>13 (21%)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*AJR 2000; 174: 901-913*  
*BMJ 2002; 325: 1387*
## Etiology

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>GENERAL</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Inflammation</strong></td>
<td>Appendicitis, cholecystitis, diverticulitis, pancreatitis, gastroenteritis, inflammatory bowel disease</td>
</tr>
<tr>
<td><strong>Obstruction</strong></td>
<td>20% of admissions for acute abdomen</td>
</tr>
<tr>
<td><strong>Perforation</strong></td>
<td>Peptic ulcer, trauma, cancer, foreign body, inflammation</td>
</tr>
<tr>
<td><strong>Vascular</strong></td>
<td>Ruptured aneurysm, ischemic bowel, hemorrhage</td>
</tr>
<tr>
<td><strong>ASSOCIATED WITH PREGNANCY</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acute pyelonephritis, acute fatty liver, acute cystitis, rupture of rectus abdominus, acute cholecystitis, uterine torsion, adnexal torsion</td>
</tr>
<tr>
<td><strong>DUE TO PREGNANCY</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ruptured ectopic, uterine rupture, chorioamnionitis, torsed exophytic myoma, HELLP syndrome/liver rupture, septic abortion/peritonitis, acute retention 20 retroversion, red degeneration of myoma</td>
</tr>
</tbody>
</table>
## Common causes in pregnancy

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute appendicitis</td>
<td>1 per 1500 pregnancies</td>
</tr>
<tr>
<td>Acute cholecystitis</td>
<td>1 per 1600-10000</td>
</tr>
<tr>
<td>Bowel obstruction*</td>
<td>1 per 2500-3500</td>
</tr>
<tr>
<td>Obstructive renal calculus</td>
<td>1 per 3300</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>1 per 1000-10000</td>
</tr>
<tr>
<td>Adnexal torsion</td>
<td>Rare</td>
</tr>
</tbody>
</table>

*Due to adhesions in 70%, volvulus in 25%*

*Clinical Obstetrics and Gynecology 2002; 45: 405-413*

*Obstet Gynecol 2000; 96 (5 Pt 1):753-6*
Why MRI?

- US often inconclusive
- More public awareness of radiation risk:
  - CT in pregnancy growing 25%/yr
- Many MDs uninformed:
  - Superficial ACOG guidelines
  - 5% would suggest TOP after CT
- Radiologists need to take the lead

AJR 2004; 182: 1107-1109
Lazarus et al, RSNA 2007
Risks of MRI

- Teratogenesis
- Gadolinium toxicity
- Acoustic damage
Teratogenesis: Chick embryo study

304 chick embryos

1.5T x 6 hours

19.5% abnormal/dead

Controls

10.7% abnormal/dead

Statistically significant difference

JMRI 1994; 4: 742-748
Gadolinium toxicity

- **Teratogenic: Skeletal malformations**
  - 0.5 mmol/kg/day x 13 days to pregnant rabbits

- No adverse effect in small human studies

- Use only if essential

*Omniscan package insert, Nycomed, Princeton, NJ*
*Radiology 1997; 205: 493-496*
## FDA and drugs in pregnancy

<table>
<thead>
<tr>
<th>Category</th>
<th>Fetal dose (rads)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>Controlled studies in women fail to demonstrate a risk to the fetus – remote possibility of fetal harm</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>IODINATED CONTRAST</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>GADOLINIUM</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>Positive evidence of human fetal risk</td>
</tr>
<tr>
<td></td>
<td>Benefits may be acceptable if the risk is high (life-threatening situation or serious disease with no other options, e.g., most chemotherapy drugs)</td>
</tr>
<tr>
<td><strong>X</strong></td>
<td>Studies in animals or women have demonstrated fetal abnormalities</td>
</tr>
<tr>
<td></td>
<td>Not to be used – absolutely contra-indication (e.g., thalidomide)</td>
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</tbody>
</table>
Acoustic damage

- Follow-up of 20 children after fetal EPI:
  - 16/18 passed hearing test at 8/12 (16.7 expected)

- Intragastric sound intensity measurement:
  - Fetal exposure < maternal

Br J Radiol 1995; 68: 1090-1094
Consent?

- No requirement – *but* ACR guidelines:
  - Attending radiologist considers study justified
  - Document lack of non-ionizing options, likely impact of results on patient/fetus care, and need for study before delivery in report or medical record
  - Give gadolinium only after well-documented and thoughtful risk–benefit analysis
  - *Recommends* written informed consent

- UCSF practice:
  - Explain negligible nature of the risk to patient and document this discussion in either the chart or the radiology report


*AJR 2007; 188:1447-1474*
Technique: Ultrafast sequences

- “Freeze” motion
- Mother supine or left lateral decubitus
- T1: Multislice spoiled GE
  - FMPSPGR (GE)
  - Multiplanar FLASH (Siemens)
- T2: Single-shot RARE
  - SSFSE (GE)
  - HASTE (Siemens)
Steady state GE

SSFSE (HASTE)  
FIESTA (True FISP, bFFE)

JMRI 2007; 26: 672-7
Acute appendicitis in pregnancy

- Major indication for surgery in pregnancy:
  - 1 in 1500 pregnancies
  - Diagnosis clinically difficult, 25% perforation rate

- Limited data on role of imaging:
  - CT 100% accurate (n = 2 of 7)
  - US 100% sensitive & 96% specific (n = 15 of 42)
  - US could not be performed in 3 (all > 35 weeks)

Mil Med. 1999; 164: 671-674
Am J Obstet Gynecol 2001; 184: 954-957
AJR 1992; 159: 539-542
Appendix hard to see near term

34 weeks

APPENDIX

37 weeks

APPENDIX?
MRI for appendicitis in pregnancy

Dutch study of 12 suspected cases:
- Mean gestational age of 17 weeks (range, 7-35)
- 3 with surgically proven appendicitis

<table>
<thead>
<tr>
<th></th>
<th>True positive</th>
<th>True negative</th>
<th>Not seen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>US</strong></td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td><strong>MRI</strong></td>
<td>3</td>
<td>7</td>
<td>2*</td>
</tr>
</tbody>
</table>

*17 and 35 weeks gestation

AJR 2004; 183: 671-675
Examples

Positive cases

Normal appendix
MRI for appendicitis in pregnancy

- Beth Israel study of 51 suspected cases:
  - Mean gestational age of 20 weeks (range, 4-38)
  - Oral Gastromark/Readi-Cat mix (dark on T1 & T2)
  - Three planes of SSFSE

- Sensitivity of 100%, specificity of 93.6%:
  - Only 4 “proven” appendicitis (3 surgical, 1 CT)
  - Gestational ages of 13, 20, 27, and 31 weeks

Radiology 2006; 238: 891-899
MRI for appendicitis in pregnancy

**Normal**

**Positive**

- Arrow indicates presence of appendicitis
- C denotes specific location or feature
UCSF experience

**TRUE POSITIVE**

34 weeks

**TRUE NEGATIVE**

31 weeks
TRUE NEGATIVE

32 weeks

UCSF experience

TRUE NEGATIVE

26 weeks

CT prior to pregnancy

?
UCSF experience

**SMALL BOWEL OBSTRUCTION**

**FORNICEAL RUPTURE**

18 weeks

14 weeks
UCSF experience

**ASYMMETRICALLY ENLARGED RIGHT OVARY**

**HYPERINTENSE ON T2**

Massive ovarian edema – may be subacute/chronic torsion

27 weeks
UCSF experience

**INDETERMINATE BY MRI**

**PYELONEPHRITIS SUGGESTED BY CT**

36 weeks
Flank pain

- Hydronephrosis common in pregnancy:
  - Probably mechanical
  - Consider stones, etc if symptomatic

- Imaging options:
  - US, NECT, IVP, isotope renography, MRU
  - No established optimal approach
Imaging stones in pregnancy

- Incidence: 0.3 per 1000 deliveries

- Detection of calculi by first test (n = 57):
  - Renal US - 21 of 35 (60%)
  - AXR - 4 of 7 (57%)
  - IVP - 13 of 14 (93%)

- Estimated fetal doses:
  - IVP = 1.4 rad
  - \textit{CT} = 2.6 rad

Obstet Gynecol 2000; 96: 753-756
Am Fam Physician 1999; 59: 1813-1818
AJR 2002; 178:1285-1286
Examples

38 weeks
FORNICEAL RUPTURE

LEFT URETERAL STONE

31 weeks
MRU in pregnancy

Two techniques for MRU:
- Static - heavily T2W images
- Dynamic (MREU) - serial T1W images after standard dose of gadolinium
- **BUT gadolinium is teratogenic!!**

Alternative to IVU?
- Stones seen in 4/15 patients\(^1\)
- MREU/MAG3 concordant in 8/9 cases\(^2\)

Red degeneration of leiomyoma

- 209 leiomyomas in 12,600 pregnancies:
  - 70% shrunk or resolved (ischemia, technical)
  - 15% grew (hormones, edema)
  - 15% unchanged

- Red degeneration is rare:
  - Acute venous infarction
  - Pain, fever, leukocytosis
  - US - no specific features
  - **MRI – Bright on T1**

*J Ultrasound Med 1994; 13: 399-401*
Red degeneration

T1 localizer

SS-RARE T2 axial
Take home points

◆ Suspected appendicitis:
  – All modalities limited near term
  – Try US first, then MRI

◆ Suspected renal colic:
  – Try US first, then MRI or CT or limited IVP?
  – MRI limited for stones, but may show other causes

◆ “Aunt Minnies” for MRI:
  – Red degeneration of leiomyoma
  – Massive ovarian edema
25 year old woman at 28 weeks gestation with acute RLQ pain