MRI of Acute Abdominal Pain in Pregnancy

Ivan Pedrosa, M.D.

Chief of MRI

Jack Reynolds MD Chair in Radiology
Associate Professor of Radiology
UT Southwestern Medical Center
Advanced Imaging Research Center

Wednesday, October 3, 2012
NON SURGICAL
- Ligamentous Laxity
- Hemorrhagic Corpus Luteum
- Degenerating Fibroids
- GU tract
- GI tract

SURGICAL
- Acute Appendicitis
- Ectopic Pregnancy
- Ovarian Torsion
Location of the Appendix

Baer et al. JAMA 1932
Location of the Appendix

Baer et al. JAMA 1932

Pedrosa et al. Radiology 2006
Oto et al. AJR 2006

Spearman Rank Correlation: 0.44 (P-value: 0.003)
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Location of the Appendix
Tilting of the Cecum

Spearman Correlation Coefficient:
0.52 (P < 0.001)
Tilting of the Cecum

Tilting of the Cecum

Tilting of the Cecum

Tilting of the Cecum

Tilting of the Cecum

specifiCity 98%

MRI Protocol
MRI Protocol

US prior to MRI
MRI Protocol

- US prior to MRI
- 1.5T (No 3T)
MRI Protocol

- US prior to MRI
- 1.5T (No 3T)
- No Gadolinium
MRI Protocol

- US prior to MRI
- 1.5T (No 3T)
- No Gadolinium
- Supine, Phase Array Body Coil
MRI Protocol

- US prior to MRI
- 1.5T (No 3T)
- No Gadolinium
- Supine, Phase Array Body Coil
- Oral prep (1.5 hours)
  - 450 mL *Gastromark* (Mallinckrodt Medical Inc., St. Louis, MO)[iron oxide]
  - 300 mL *Readi-cat 2* (EZEM Canada Inc., Westbury, NY)[barium sulfate]

Liebig, T et al. Mag Reson Med 1993
MRI Protocol

- US prior to MRI
- 1.5T (No 3T)
- No Gadolinium
- Supine, Phase Array Body Coil

- Oral prep (1.5 hours)
  - 450 mL *Gastromark* (Mallinckrodt Medical Inc., St. Louis, MO) [iron oxide]
  - 300 mL *Readi-cat 2* (EZEM Canada Inc., Westbury, NY) [barium sulfate]

Liebig, T et al. Mag Reson Med 1993
MRI Protocol
MRI Protocol

T2W SSFSE / HASTE (T2-WI)

- Axial
- Coronal
- Sagittal
MRI Protocol

- T2W SSFSE / HASTE (T2-WI)
  - Axial
  - Coronal
  - Sagittal

- Axial T2W Fat-Sat SSFSE / HASTE
MRI Protocol

- T2W SSFSE / HASTE (T2-WI)
  - Axial
  - Coronal
  - Sagittal
- Axial T2W Fat-Sat SSFSE / HASTE
- Axial 2D T2* TOF
MRI Protocol

- T2W SSFSE / HASTE (T2-WI)
  - Axial
  - Coronal
  - Sagittal
- Axial T2W Fat-Sat SSFSE / HASTE
- Axial 2D T2* TOF
- Axial T1W GRE in- and out-of-phase
MRI Protocol

- T2W SSFSE / HASTE (T2-WI)
  - Axial
  - Coronal
  - Sagittal
- Axial T2W Fat-Sat SSFSE / HASTE
- Axial 2D T2* TOF
- Axial T1W GRE in- and out-of-phase
- Axial DWI (b=850)
Normal Appendix

Collapsed Intraluminal Air

Wednesday, October 3, 2012
Normal Appendix

Collapsed

Intraluminal Air
Normal Appendix

Collapsed Intraluminal Air
Is the Appendix Obstructed?

Normal/Abnormal? Normal Appendicitis

T2-W SSFSE

Air-Filled Appendix

T2W SSFSE (spin echo)  TOF (GRE)
Air-Filled Appendix

T2W SSFSE (spin echo)  TOF (GRE)
Air-Filled Appendix

T2W SSFSE (spin echo)  TOF (GRE)
Air-Filled Appendix

T2W SSFSE (spin echo)  

TOF (GRE)

Blooming Effect = Intraluminal Air

Wednesday, October 3, 2012
Air-Filled Appendix

T2W SSFSE (spin echo)  TOF (GRE)

Blooming Effect = Intraluminal Air
Air-Filled Appendix

T2W SSFSE (spin echo)  TOF (GRE)

Blooming Effect = Intraluminal Air
Appendix vs. Gonadal Varices

SSFSE
Appendix vs. Gonadal Varices

SSFSE
Appendix vs. Gonadal Varices

SSFSE

TOF
Appendix vs. Gonadal Varices

SSFSE

TOF
Appendix vs. Gonadal Varices

Intraluminal Air (Blooming)
Collapsed (intermediate signal)
Appendicitis: MR Criteria
Appendicitis: MR Criteria

**Normal**

- Diameter $\leq$ 6 mm
- Air in its lumen (blooming effect on T2* TOF)
Appendicitis: MR Criteria

**Normal**
- Diameter $\leq 6$ mm
- Air in its lumen (blooming effect on T2* TOF)

**Abnormal**
- Diameter $> 7$ mm
- Fluid-filled lumen
- Periappendiceal fat stranding
- RLQ abscess/phlegmon
Appendicitis: MR Criteria

**Normal**
- Diameter $\leq 6$ mm
- Air in its lumen (blooming effect on T2* TOF)

**Abnormal**
- Diameter $> 7$ mm
- Fluid-filled lumen
- Periappendiceal fat stranding
- RLQ abscess/phlegmon

**Inconclusive**
- Diameter between 6-7 mm without ancillary findings
Mild Appendicitis
Mild Appendicitis
Mild Appendicitis
Mild Appendicitis
Appendicitis + Appendicolith
Appendicitis + Appendicolith
Appendicitis + Appendicolith
Appendicitis + Appendicolith
Appendicitis + Appendicolith
Suppurative Appendicitis
Suppurative Appendicitis
Suppurative Appendicitis
Fat Saturation in Mild Acute Appendicitis

SSFSE

SSFSE + FS

Wednesday, October 3, 2012
Fat Saturation in Mild Acute Appendicitis

SSFSE

SSFSE + FS
Fat Saturation in Mild Acute Appendicitis

SSFSE

SSFSE + FS
Fat Saturation in Mild Acute Appendicitis

SSFSE

SSFSE + FS
Fat Saturation in Mild Acute Appendicitis

SSFSE

SSFSE + FS

Wednesday, October 3, 2012
Appendiceal Phlegmon

27 wks
Appendiceal Phlegmon

27 wks

Wednesday, October 3, 2012
Appendiceal Phlegmon

27 wks

Wednesday, October 3, 2012
Appendiceal Phlegmon

27 wks

32 wks
Appendiceal Phlegmon

27 wks

32 wks
Appendiceal Phlegmon

27 wks

32 wks
DWI in Appendicitis

SSFSE

DWI (b=1000)
DWI in Appendicitis

SSFSE

DWI (b=1000)
DWI in Appendicitis

SSFSE  DWI (b=1000)
DWI in Appendicitis

SSFSE  DWI (b=1000)  Fused
Inconclusive Result
Inconclusive Result
Inconclusive Result
Initial Experience
Initial Experience

Prospective diagnosis (51 pts): 4 TP, 3 FP, 0 FN, 44 TN
Initial Experience

Prospective diagnosis (51 pts): 4 TP, 3 FP, 0 FN, 44 TN

Sensitivity 100%, NPV 100%

Pedrosa I et al. Radiology 2006
Initial Experience

- Prospective diagnosis (51 pts): 4 TP, 3 FP, 0 FN, 44 TN
- Sensitivity 100%, NPV 100%
- 1 CT / 51 patients to confirm tip appendicitis

Pedrosa I et al. Radiology 2006
“Ruling-out” Acute Appendicitis
“Ruling-out” Acute Appendicitis

MR → normal appendix seen:
“Ruling-out” Acute Appendicitis

MR → normal appendix seen:

89% (20/23) Oto et al. Radiology 2005
“Ruling-out” Acute Appendicitis

MR → normal appendix seen:

89% (20/23) Oto et al. Radiology 2005

87% (116/134) Pedrosa et al. Radiology 2009
“Ruling-out” Acute Appendicitis

MR → normal appendix seen:

89% (20/23) Oto et al. *Radiology* 2005

87% (116/134) Pedrosa et al. *Radiology* 2009

US → normal appendix typically not seen

Negative Result = *Ambiguous result*
“Ruling-out” Acute Appendicitis

MR → normal appendix seen:

89% (20/23) Oto et al. Radiology 2005

87% (116/134) Pedrosa et al. Radiology 2009

US → normal appendix typically not seen

Negative Result = Ambiguous result

Do we need an US?
Surgical Conditions

- Ectopic Pregnancy
- Ovarian Torsion
Ovarian Torsion

MR Findings

- Tubal thickening
- Ovarian enlargement
- Hyperintense ovarian stroma on T2-W (probably related to edema)

Swirled vascular pedicle

Ghossain MA et al. JMRI 2004
Ovarian Torsion
Ovarian Torsion
Ovarian Torsion
Ovarian Torsion
Non-Surgical Conditions

- Hemorrhagic Corpus Luteum
- Degenerated Fibroids
- GU tract pathology
- GI tract pathology
- Right ovarian vein varices
Fibroid degeneration

T2-WI

T1-WI
Fibroid degeneration

T2-WI

T1-WI
Fibroid degeneration
DWI in Fibroid degeneration

T2W
SSFSE
DWI in Fibroid degeneration

T2W
SSFSE
DWI in Fibroid degeneration

T2W
SSFSE
DWI in Fibroid degeneration

T2W SSFSE

DWI (b=850)
DWI in Fibroid degeneration

T2W
SSFSE

DWI
(b=850)
DWI in Fibroid degeneration

T2W
SSFSE

DWI
(b=850)
Hydronephrosis

Pregnancy hydronephrosis

Passed Ureteral Stone

Roy C. Magn Reson Imaging 1995

Wednesday, October 3, 2012
Hydronephrosis

Pregnancy hydronephrosis

Passed Ureteral Stone
Hydronephrosis

Pregnancy hydronephrosis

Passed Ureteral Stone

Roy C. Magn Reson Imaging 1995
Hydronephrosis

Pregnancy hydrenephrosis

Passed Ureteral Stone

Roy C. Magn Reson Imaging 1995
Hydronephrosis

Pregnancy hydronephrosis

Passed Ureteral Stone
Ureteral Stone
Ureteral Stone
Ureteral Stone
Ureteral Stone

Pseudo-stone
Ureteral Stone

Pseudo-stone
Ureteral Stone
Ureteral Stone
Ureteral Stone
Ureteral Stone

Fat Sat SSFSE
Ureteral Stone

Fat Sat SSFSE

3D FIESTA
Ureteral Stone

Fat Sat SSFSE

3D FIESTA
Ureteral Stone

Fat Sat SSFSE

3D FIESTA
Pyelonephritis

T2 FSE FS

Dipstick Urinalysis: -

Wednesday, October 3, 2012
Pyelonephritis

T2 FSE FS

Dipstick Urinalysis: -
Pyelonephritis

Dipstick Urinalysis: -

T2 FSE FS

DWI (b=1000)
Pyelonephritis

T2 FSE FS

Dipstick Urinanalysis: -

DWI (b=1000)

Wednesday, October 3, 2012
Pyelonephritis

Dipstick Urinalysis: -

T2 FSE FS

DWI (b=1000)
Pyelonephritis

T2 FSE FS

Dipstick Urinanalysis: -

DWI (b=1000)

Final culture: Gram +

Wednesday, October 3, 2012
## Clinical Outcomes (2002-07)

<table>
<thead>
<tr>
<th></th>
<th>All patients</th>
<th>Estimated (MRI negative)</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laparotomy Rate</strong></td>
<td>30%</td>
<td>7%</td>
<td>20-52%</td>
</tr>
<tr>
<td><strong>Perforation Rate</strong></td>
<td>21%</td>
<td>21%</td>
<td>55%</td>
</tr>
</tbody>
</table>

Pedrosa et al. Radiology 2009
Conclusion
Conclusion

Dx of Surgical and Non-surgical dz
Conclusion

- Dx of Surgical and Non-surgical dz
- Anatomic changes in right colon
Conclusion

- Dx of Surgical and Non-surgical dz
- Anatomic changes in right colon
- MRI Protocol - short but comprehensive
Conclusion

- Dx of Surgical and Non-surgical dz
- Anatomic changes in right colon
- MRI Protocol - short but comprehensive
- MRI findings in acute appy, other GI dz, ovarian torsion, degenerating fibroids, ureteral stone vs pregnancy-hydro