# UC San Diego
## Independent Study Projects

### Title
Defining the role of ultrasound in the imaging workup for suspected acute apprendicitis in children at Rady Children's Hospital San Diego

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# Is sonography the most appropriate imaging modality for diagnosing acute appendicitis in children?

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UC San Diego Health
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# Disclosure of commercial interest

Neither I nor my immediate family members have a financial relationship with a commercial organization that may have a direct or indirect interest in the content

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# Background

- American College of Radiology considers ultrasound to be the most appropriate imaging modality for the initial evaluation of acute appendicitis: lack of ionizing radiation, high sensitivity, and low cost
- Rady Children's Hospital San Diego (RCHSD) has historically used CT or MR
- On January 1, 2016, we implemented a protocol to use abdominal ultrasound ("U/S Appy"), and not computed tomography (CT) or magnetic resonance imaging (MR), in the initial assessment of suspected appendicitis

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# Background cont.

- In this quality improvement project we:
  1. Highlight the limitations of sonography in diagnosis of acute appendicitis
  2. Describe “non-visualized appendix” on imaging report
  3. Show how to include “non-visualized” studies in sensitivity and specificity calculation
  4. Highlight the advantages of sonography in diagnosis of acute appendicitis
  5. Review the importance of adequate sonographer training/competence

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# Purpose

- The goals of this retrospective chart review quality improvement project were to evaluate
  - If U/S is the more appropriate initial imaging modality based on diagnostic test performance variables (DTPV)
  - DTPV = sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV)
  - Which variables (gender, BMI, etc.) affect the DTPVs

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# Materials, Methods, and Procedures

- This was a retrospective chart review quality improvement project
- Patients with U/S Appy ordered between February 1, 2016 and March 31, 2016 were included in the test group (n=300)
- Patients with CT or MR ordered for suspected appendicitis between February 1, 2015 and March 31, 2015 were included in the control group (n=300)

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# Materials, Methods, and Procedures

- The following data was collected for each patient:
  - gender
  - age
  - body mass index (BMI)
  - sonographer
  - length of stay
  - pathology results
  - other imaging studies performed
  - pertinent history, physical exam results, and labs

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# Materials, Methods, and Procedures

- Positive predictive value, negative predictive value, sensitivity, and specificity of ultrasound results were calculated based on pathology results

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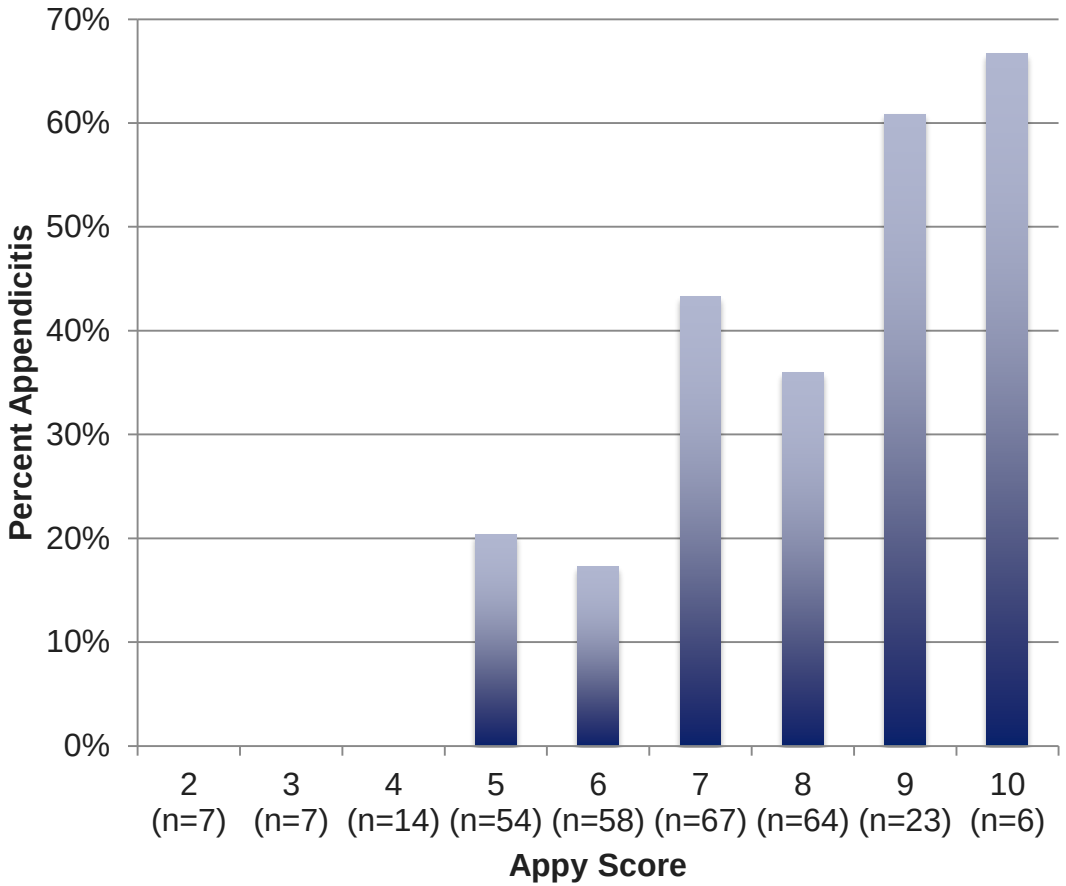
# “Appy score” positively correlates with appendicitis

## Appy score (max of 10 points):

- RLQ pain (2pt)
- RLQ tenderness to palpation (2pt)
- WBC>11K (1pt)
- Neutrophils >75% (1pt)
- CRP >1 (1pt)
- Nausea/vomiting (1pt)
- Rebound tenderness (1pt)
- Fever > 38.0 (1pt)

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# Study groups were not statistically different in clinical presentation, gender, or BMI

**Test Group**: Patients with U/S Appy ordered between 2/1/16 and 3/31/16
**Control Group**: Patients with CT Abdomen Pelvis or MR Appy studies ordered between 2/1/15 and 3/31/15

| | Ultrasound (n=300) | CT/MRI (n=300) |
|---|---|---|
| **Clinical Presentation/Appy Score+*** | 6.3 +/- 1.8 | 6.5 +/- 1.7 |
| **% Females*** | 47% | 47% |
| **Age** | 9.7 +/- 4.3 | 9.0 +/- 4.2 |
| **BMI*** | 21.3 +/- 9.8 | 20.4 +/- 6 |

+Clinical presentation is defined by appy score
*p<0.05

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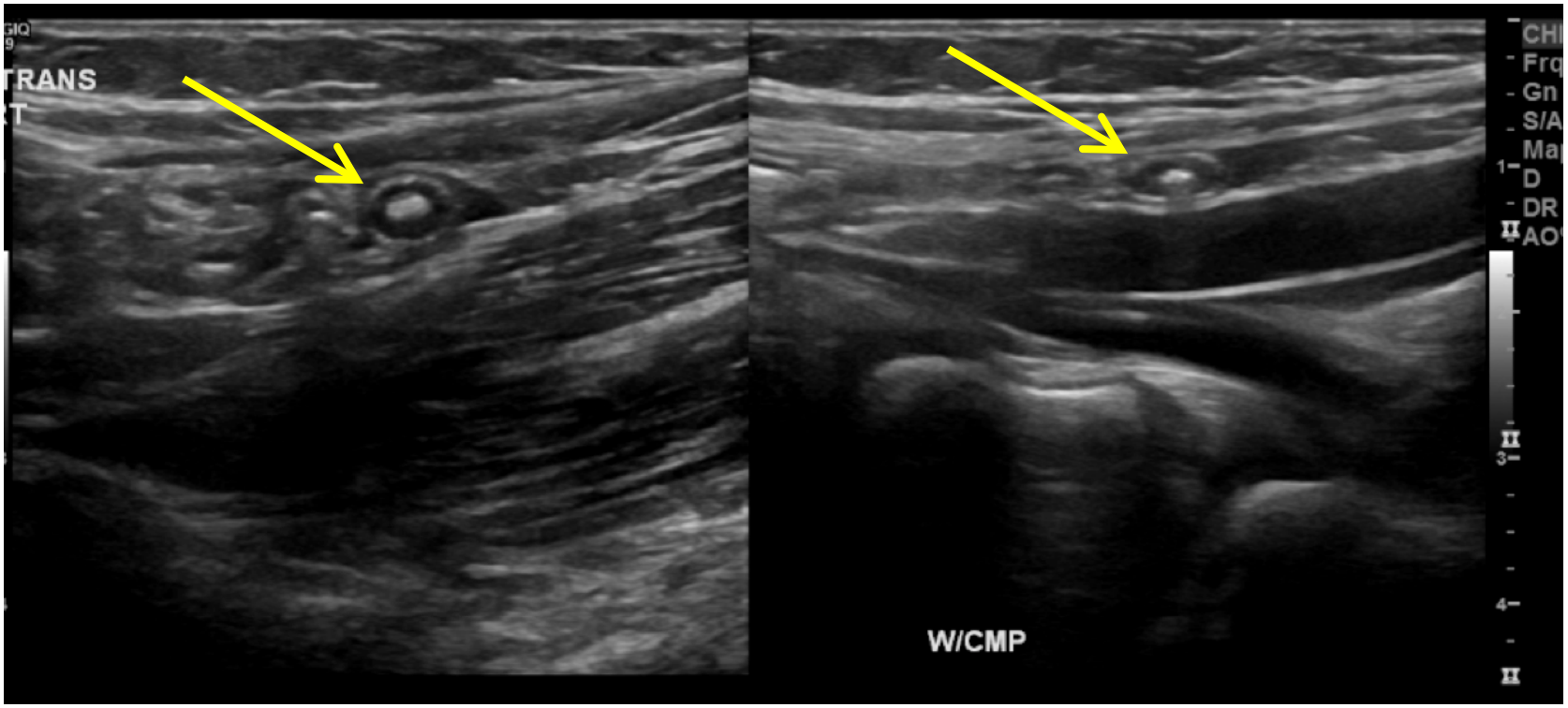
# U/S: Normal Appendix




Appendix is identified, less than 6 mm in diameter, and compressible

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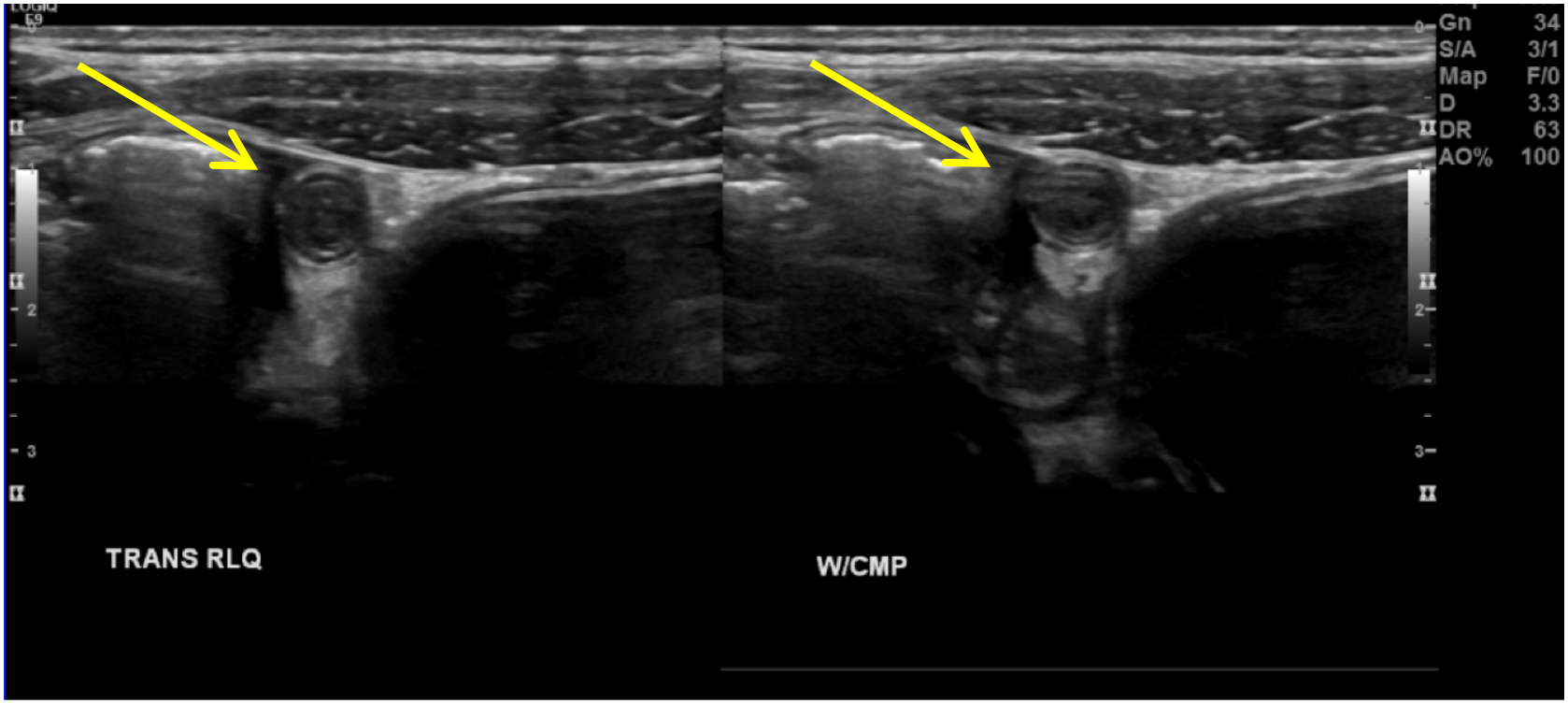
# U/S: Appendicitis




Appendix is visualized, enlarged (8mm in diameter), and incompressible

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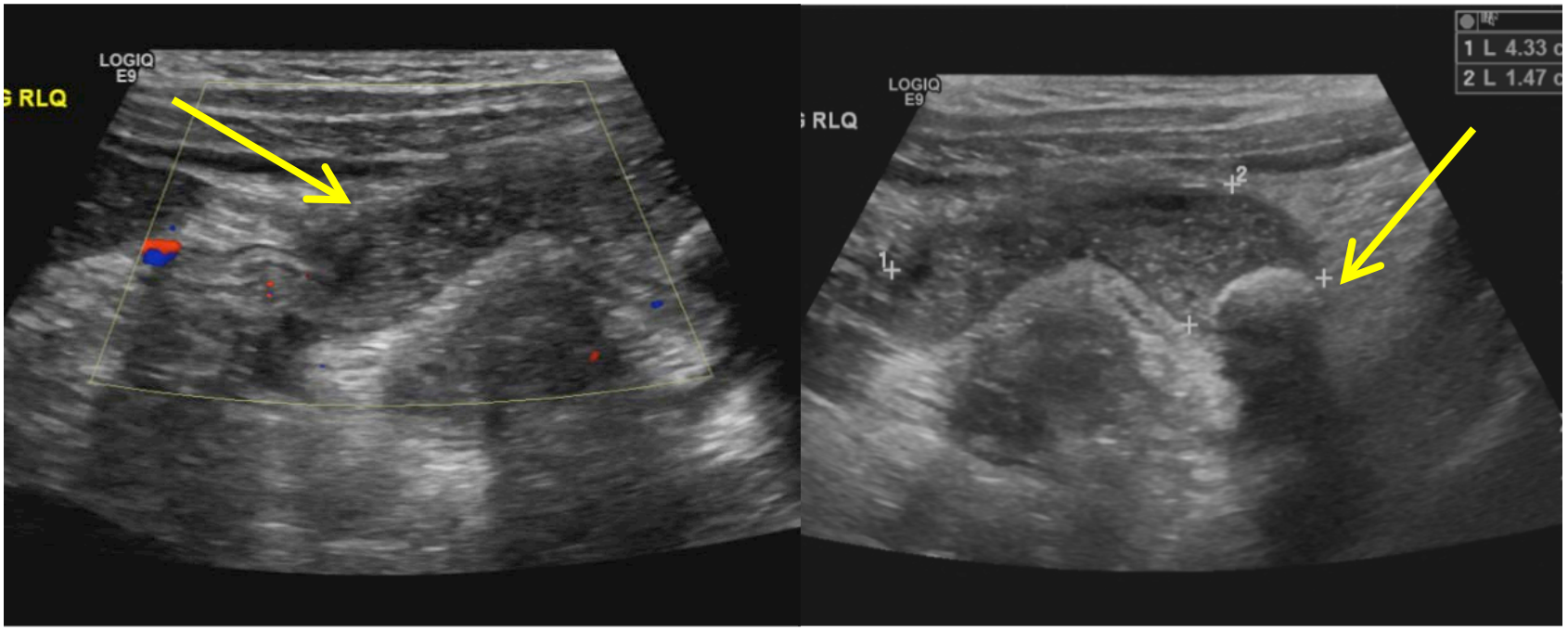
# U/S: Appendicitis with appendicolith




Appendix visualized, enlarged (16mm in diameter), and mildly inflamed with associated appendicolith and decreased blood supply on Doppler

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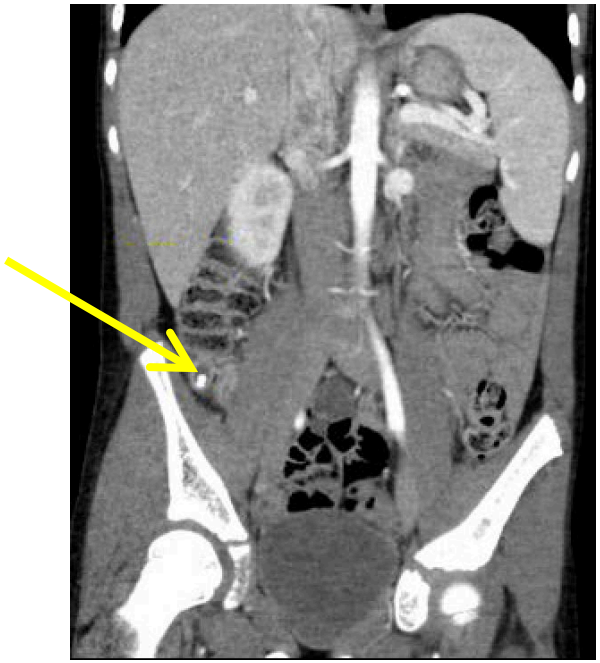
# CT: Acute appendicitis with appendicoliths



Appendix is dilated up to 1 cm in maximum diameter, with hyperemic walls, multiple appendicoliths within its lumen. There is right lower quadrant inflammatory change.

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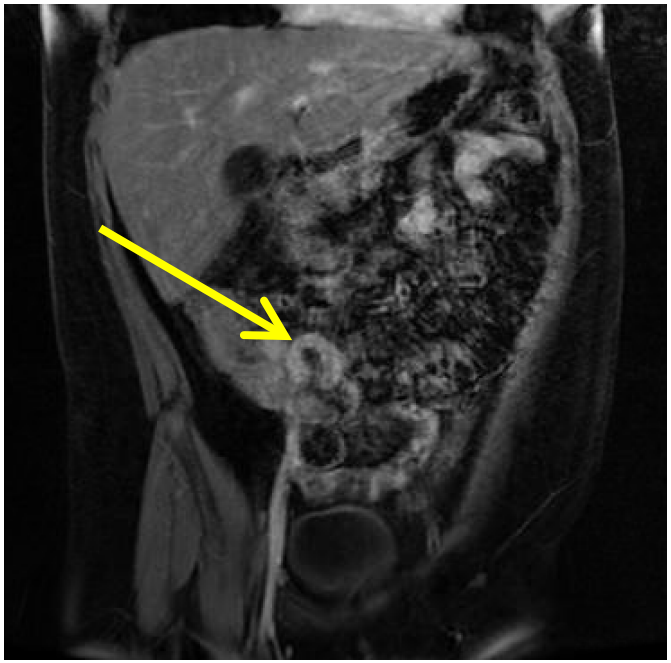
# MR: Acute Appendicitis



The appendix is visualized and has a diameter of 8.6 mm. Appendiceal wall appears thickened and hyperenhancing. No free fluid.

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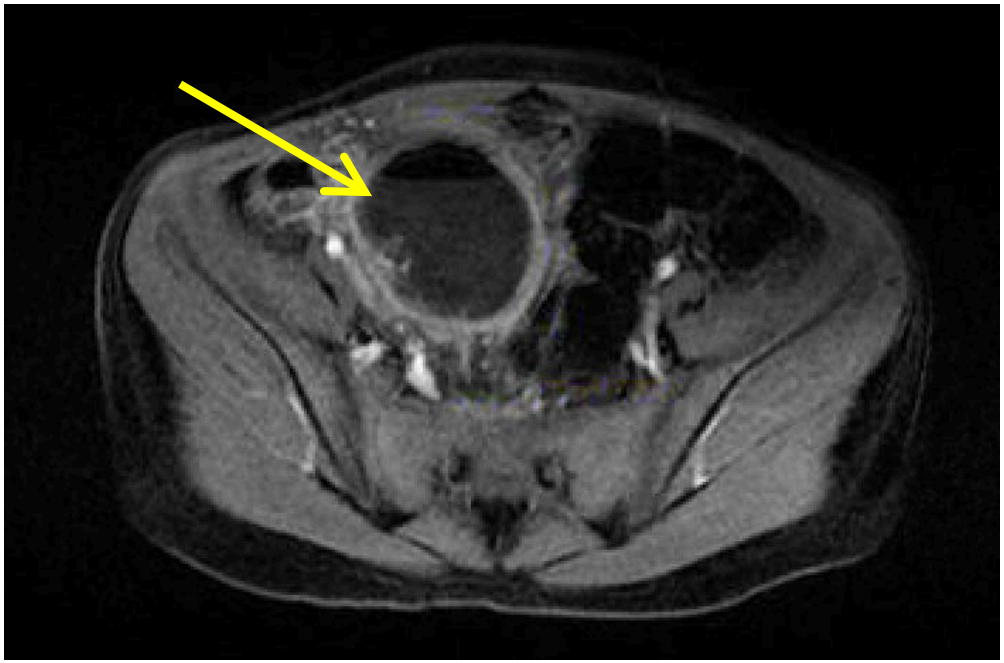
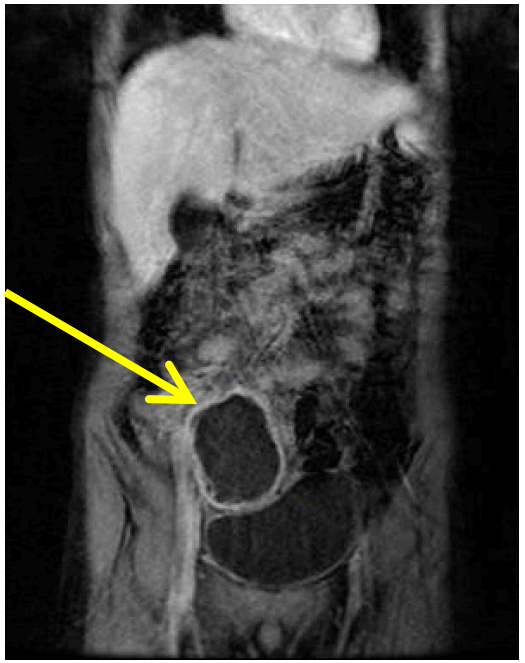
# MR: Appendiceal Abscess





A 5.5 x 5.6 x 6.7 cm abscess (see arrows) within the right lower quadrant, most likely sequelae of a ruptured appendicitis. Small amount of free fluid within the abdomen /pelvis.

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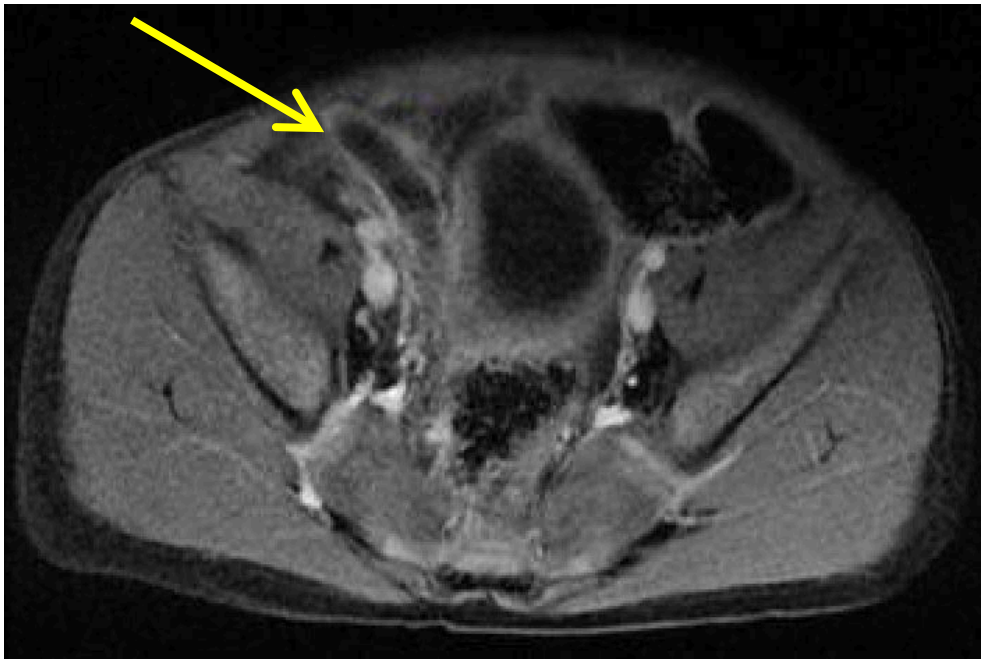
# MR: Acute Appendicitis



Abnormal appendix, measuring up to 1.4 cm and demonstrating wall thickening, and hyperenhancement. There is prominent periappendiceal stranding, with ill-defined enhancement. There is a moderate amount of free pelvic fluid.

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# Imaging modality

| Imaging Modality | sensitivity | specificity | PPV | NPV | Non-visualized | Positive appys that were non-visualized on U/S (%) |
|---|---|---|---|---|---|---|
| **U/S (n=300)** | 53% | 13% | 92% | 96% | 72% | 18% |
| **CT (n=195)** | 96% | 96% | 98% | 99% | 3% | 0% |
| **MR (n=105)** | 97% | 96% | 97% | 99% | 2% | 0% |

U/S Appy currently has lower diagnostic test performance than CT or MRI

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# Non-visualized appendix on U/S does not equate to negative study

| Imaging Modality | sensitivity | specificity | PPV | NPV | Non-visualized | Positive appys that were non-visualized on U/S (%) |
|---|---|---|---|---|---|---|
| **U/S (n=300)** | 53% | 13% | 92% | 96% | **72%** | **18%** |
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The appendix was non-visualized in 72% of the U/S studies – 18% of these were positive on further imaging and on pathology. Therefore, one cannot assume the patient does not have appendicitis if the appendix was non-visualized on U/S (this assumption can be made, however, for CT and MRI).

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# Additional studies were ordered more often after U/S Appy vs. CT/MR

- Test group (U/S Appy): 0.8 ± 0.8 additional studies per patient
  - 33% had CT abdomen pelvis after U/S
  - 15% had MRI Appy after U/S
  - 1% had both CT and MRI after U/S
- Control group (CT/MRI): 0.2 ± 0.5 additional studies per patient

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# Sedation and average length of stay

- Sedation was more likely to be used with CT (7.7%) or MR (2.9%) vs. U/S (0%)
- Average length of stay was greater for CT/MRI cases (1.5 ± 4 days) vs. U/S (1.0 ± 1.7 days)

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# Gender: Diagnostic test performance of U/S Appy decreases for females vs. males

| Gender | sensitivity | specificity | PPV | NPV | Non-visualized | Positive appys that were non-visualized on U/S (%) |
|---|---|---|---|---|---|---|
| Female (140) | 45% | 12% | 83% | 92% | 73% | 16% |
| Male (160) | 58% | 14% | 97% | 100% | 69% | 21% |
| **Overall** | **53%** | **13%** | **92%** | **96%** | **72%** | **18%** |

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# BMI: Diagnostic test performance of U/S Appy decreases for BMI > 30

| BMI | sensitivity | specificity | PPV | NPV | Non-visualized | Positive appys that were non-visualized on U/S (%) |
|---|---|---|---|---|---|---|
| BMI < 30 (n=197) | 55% | 12% | 96% | 93% | 67% | 27% |
| BMI > 30 (n=11) | 0% | 20% | N/A | 100% | 82% | 11% |
| **Overall** | **53%** | **13%** | **92%** | **96%** | **72%** | **18%** |

Additional advanced imaging (MR or CT) was ordered in 82% (9/11) of the cases when BMI > 30 vs. 46% when BMI < 30

BMI could not be calculated for 92 patients, due to lack of height and/or weight data

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# Sonographer: Diagnostic test performance is influenced by sonographer proficiency

| Sonographer | sensitivity | specificity | PPV | NPV | Non-visualized | Positive appys that were non-visualized on U/S (%) |
|---|---|---|---|---|---|---|
| A (n=101) | 52% | 4% | 85% | 100% | 60% | 16% |
| B (n=36) | 50% | 10% | 100% | 100% | 67% | 14% |
| C (n=36) | 63% | 8% | 100% | 100% | 69% | 8% |
| D (n=8) | 0% | 0% | N/A | N/A | 88% | 13% |
| E (n=22) | 83% | 20% | 100% | 100% | 59% | 5% |
| F (n=71) | 52% | 41% | 100% | 94% | 45% | 13% |
| G (n=10) | 25% | 0% | 100% | N/A | 60% | 30% |
| H (n=16) | 67% | 0% | 80% | N/A | 56% | 13% |
| **Overall** | **53%** | **13%** | **92%** | **96%** | **72%** | **18%** |

# Sonographer

| Sonographer | sensitivity | specificity | PPV | NPV | Nonvisualized | Positive appys that were nonvisualized on U/S (%) |
|---|---|---|---|---|---|---|
| Range | 0-83% | 0-41% | 80-100% | 94-100% | 45-88% | 5-30% |
| Potential | 83% | 41% | 100% | 100% | 45% | 5% |
| **Overall** | **53%** | **13%** | **92%** | **96%** | **72%** | **18%** |

There is potential for improved diagnostic test performance by advanced training and experience

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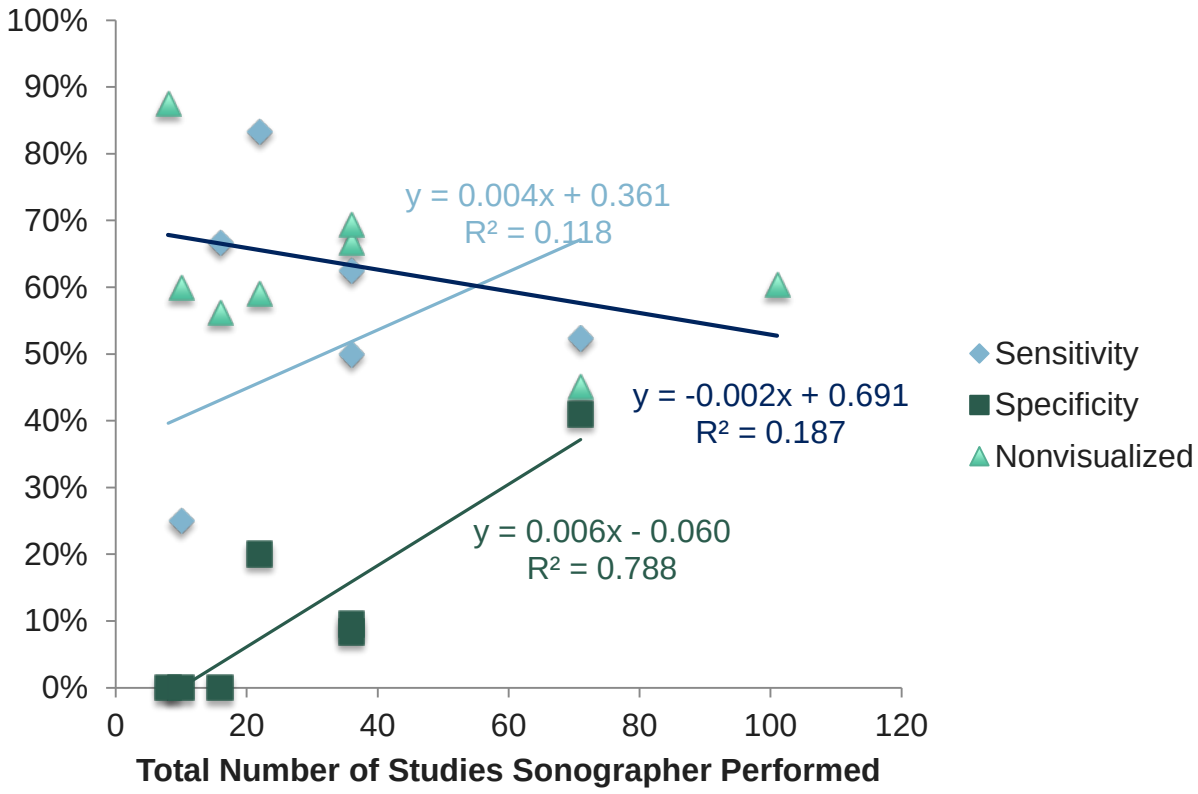
# Sonographer: Specificity is strongly correlated with experience

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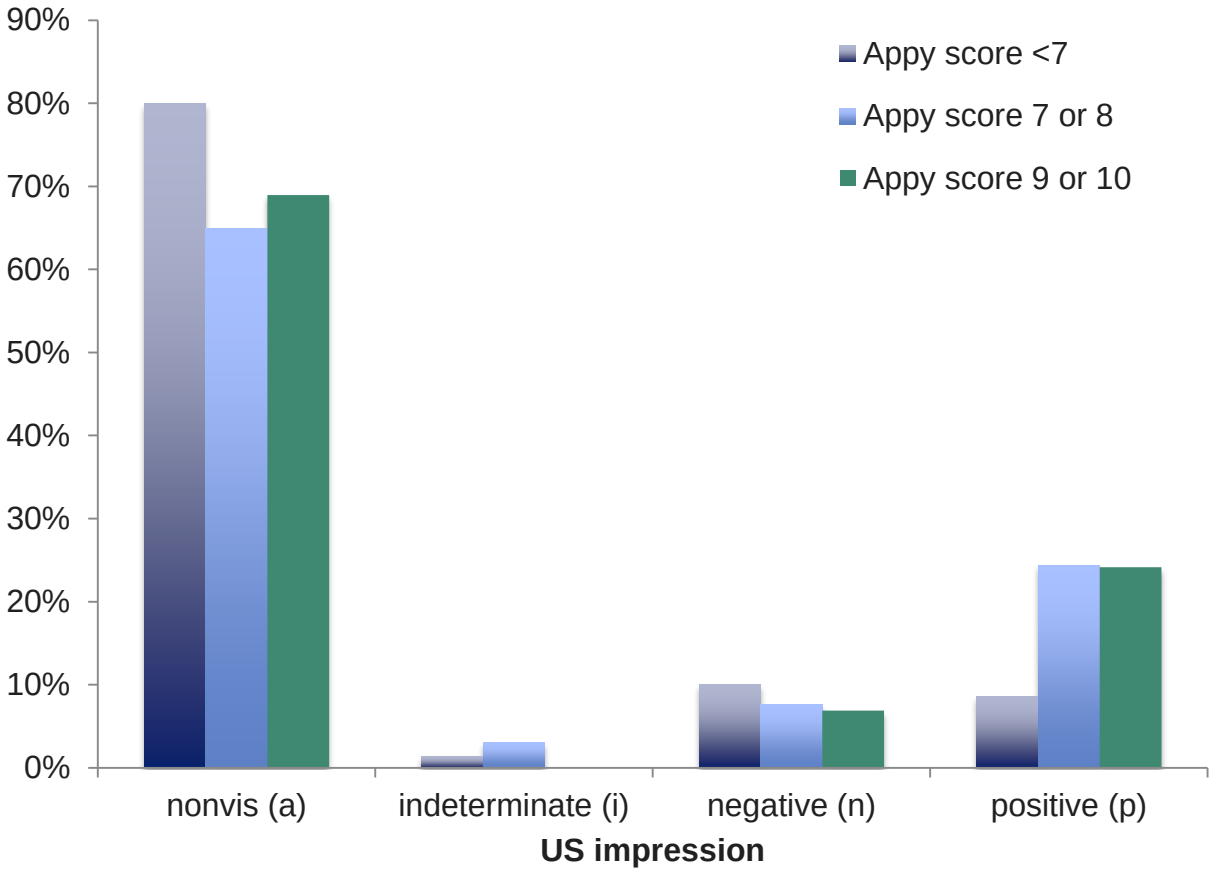
# Approximately 1 out of every 4 appendicitis cases with Appy Score > 7 had a positive U/S Appy study

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# Conclusion

- On average, more studies were ordered per patient after U/S Appy (0.8 +/- 0.8) vs CT or MR (0.2 +/- 0.5)
- Sedation was more likely to be used with CT (7.7%) or MR (2.9%) vs. U/S (0%)
- Average length of stay was greater for patients who had CT/MRI ordered (1.5 ± 4 days) vs. U/S (1.0 ± 1.7 days)
- All Diagnostic Test Performance Variable (DTPV) values were lower for females compared to males, and for BMI > 30
- DTPV was greatly influenced by sonographer proficiency

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# Significance of Conclusions

- “Non-visualized appendix” on U/S should not be interpreted as a negative study since it affects the sensitivity and specificity
- Ultrasound requires sedation less often, generates less total studies ordered per patient, and is associated with decreased average length of stay
- With increased experience/training of sonographers, there is improve “U/S Appy” diagnostic test performance

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# Limitations of U/S in diagnosis of acute appendicitis

- High proportion of non-visualized studies that were actually positive on further imaging/pathology
- BMI > 30
- Females
- Sonographer proficiency
- Increased experience and/or training of sonographers may greatly improve “U/S Appy” diagnostic test performance

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# Advantages of U/S compared to CT and MRI

- Sedation used less often
- Less total studies ordered per patient
- Decreased average length of stay

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# Thank you for viewing E2492

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