

Magnetic Resonance Imaging Versus Ultrasound as the Initial Imaging Modality for Pediatric and Young Adult Patients With Suspected Appendicitis

AUTHORS

DANIEL IMLER, MD, CHRISTINE KELLER, SHYAM SIVASANKAR, MD, NANCY EWEN WANG, MD,
SHREYAS VASANAWALA, MD, PHD, MATIAS BRUZONI, MD, AND JAMES QUINN, MD

AFFILIATIONS

•¹DEPARTMENT OF EMERGENCY MEDICINE, STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA.

•²DEPARTMENT OF RADIOLOGY (PEDIATRIC RADIOLOGY), STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA.

•³DEPARTMENT OF SURGERY (PEDIATRIC SURGERY), STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA.

DAN MOORE, MS4, RADY JOURNAL CLUB 7/7/20

Learning Objectives

- ▶ By the end of this journal club, participants will:
 - ▶ Know the epidemiology, pathophysiology, and etiology of appendicitis
 - ▶ Be familiar the different presentations of appendicitis
 - ▶ Be able to assess different imaging modalities in the approach to pediatric abdominal pain

Module Outline

- ▶ I. Case
- ▶ II. Background
- ▶ III. Article Overview
- ▶ IV. Clinical Questions
- ▶ V. Key Points

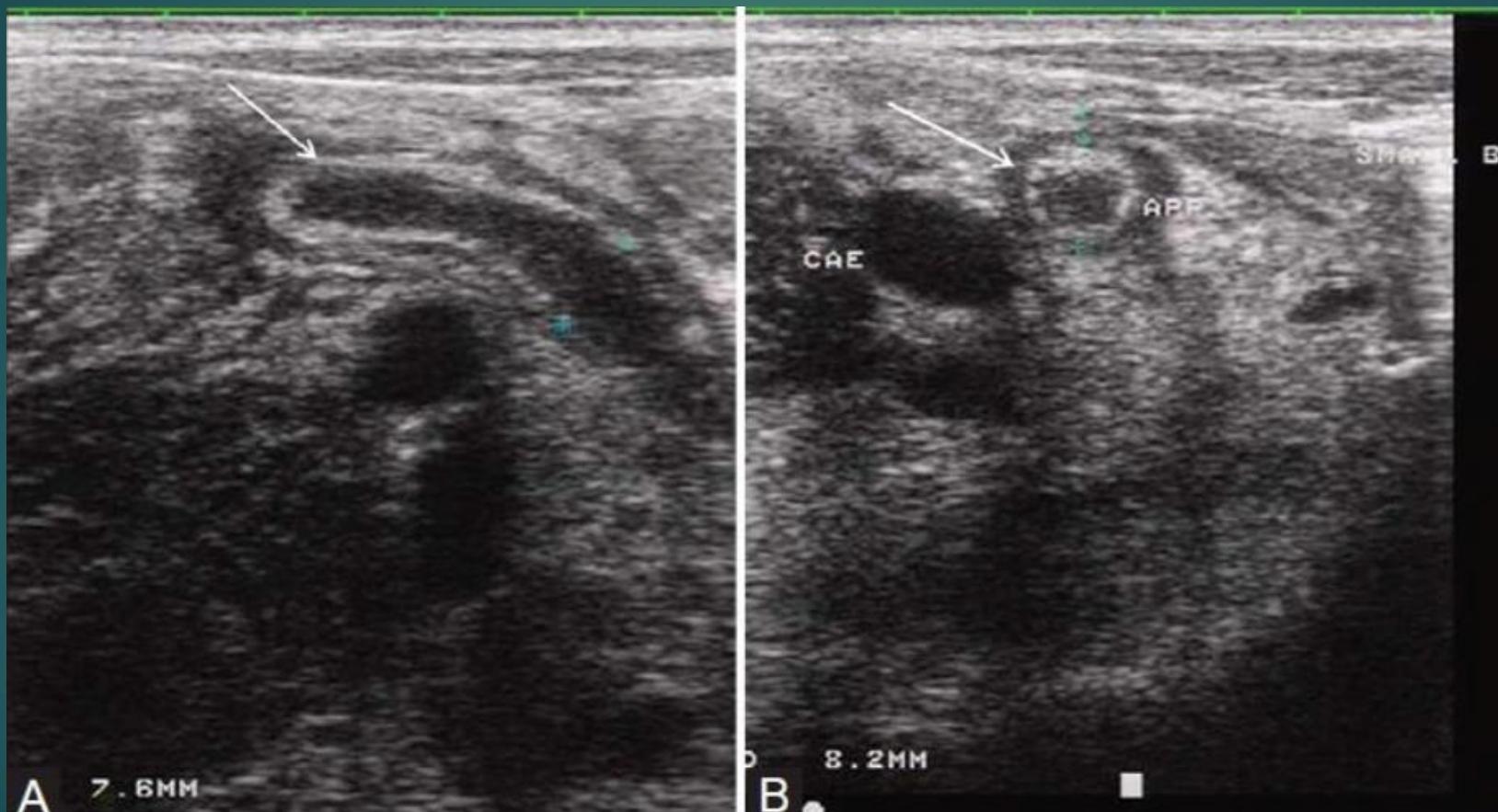
Case

- ▶ 9 yo F with no significant PMH presents to UNC ED with 12 hour history of increasing abdominal pain. Also complains of low-grade fever, nausea, vomiting, and anorexia
- ▶ BP 107/55, Pulse 110, T 100.8, RR 24, SpO₂ 100%
- ▶ Physical exam is remarkable for RLQ pain with guarding and rebound tenderness present

Case questions

- ▶ 1. What is your differential diagnosis for increasing abdominal pain in 9 yo F?
- ▶ 2. What labs and imaging studies would you order?
- ▶ 3. Next steps?

Imaging



Sargar 2014

Case

- ▶ Patient underwent targeted ultrasound
 - ▶ Diagnosis: appendicitis
- ▶ Treatment
 - ▶ Laparoscopic appendectomy

Case – Questions to Consider

- ▶ When should you suspect pediatric appendicitis?
- ▶ What should guide your preferred imaging modality when appendicitis is high on your differential?

Module Outline

- ▶ I. Case
- ▶ II. **Background**
- ▶ III. Article Overview
- ▶ IV. Clinical Questions
- ▶ V. Key Points

Case

- ▶ Epidemiology
 - ▶ Annually, up to 250,000 cases of appendicitis are reported. The estimated lifetime risk is 12% for males and 25% for females. Although appendicitis can occur at any age, it most commonly occurs between the ages of 10 and 19 years.¹
- ▶ Pathophysiology
 - ▶ Luminal obstruction and continued appendiceal mucous production leads to luminal distension and eventual rupture of the appendix

Case

- ▶ Symptomatology
 - ▶ Classically periumbilical pain that migrates to McBurney point
 - ▶ Can also present with pelvic, flank, RUQ and LLQ pain depending on anatomical position¹
 - ▶ Fever, nausea, vomiting, diarrhea, anorexia
 - ▶ Physical Exam
 - ▶ Rebound tenderness in RLQ
 - ▶ Psoas/Rosving/Obturator sign
 - ▶ Lab Findings
 - ▶ Elevated WBC count
- ▶ Etiology
 - ▶ Appendicitis in children is usually caused by lymphoid hyperplasia¹
 - ▶ In children it can rarely also be caused by fecaliths and other obstructing masses

Case Cont.

- ▶ Imaging Modalities:
 - ▶ Ultrasound → Incompressible, >6 mm thickened appendix¹
 - ▶ Low-cost
 - ▶ No ionizing radiation exposure
 - ▶ Limited by habitus
 - ▶ Operator-dependent
 - ▶ MRI¹
 - ▶ Higher cost
 - ▶ More time required
 - ▶ Need MRI-trained radiologist
 - ▶ MRI not always available
 - ▶ CT
 - ▶ Most common imaging ordered prior to surgery
 - ▶ Concern for radiation exposure^{3,4}

Module Outline

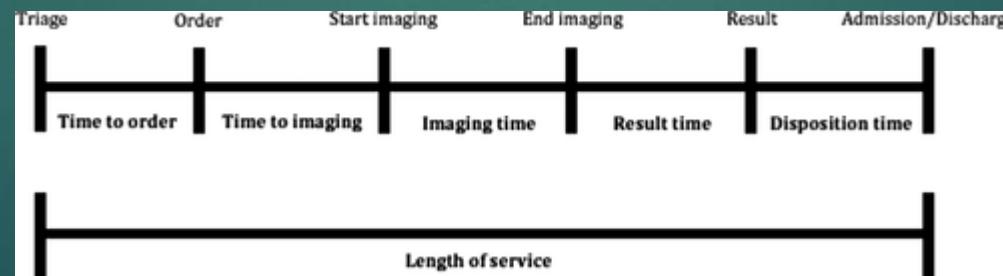
- ▶ I. Case
- ▶ II. Background
- ▶ III. **Article Overview**
- ▶ IV. Clinical Questions
- ▶ V. Key Points

Journal Article Overview

- ▶ Purpose: A study of rapid MRI as a first-line imaging evaluation of suspected pediatric appendicitis
- ▶ Journal: Journal for the American Academy of Emergency Medicine (JEM)
- ▶ Study Type: Prospective randomized cohort trial of 82 patients ages 2-30 with suspected appendicitis

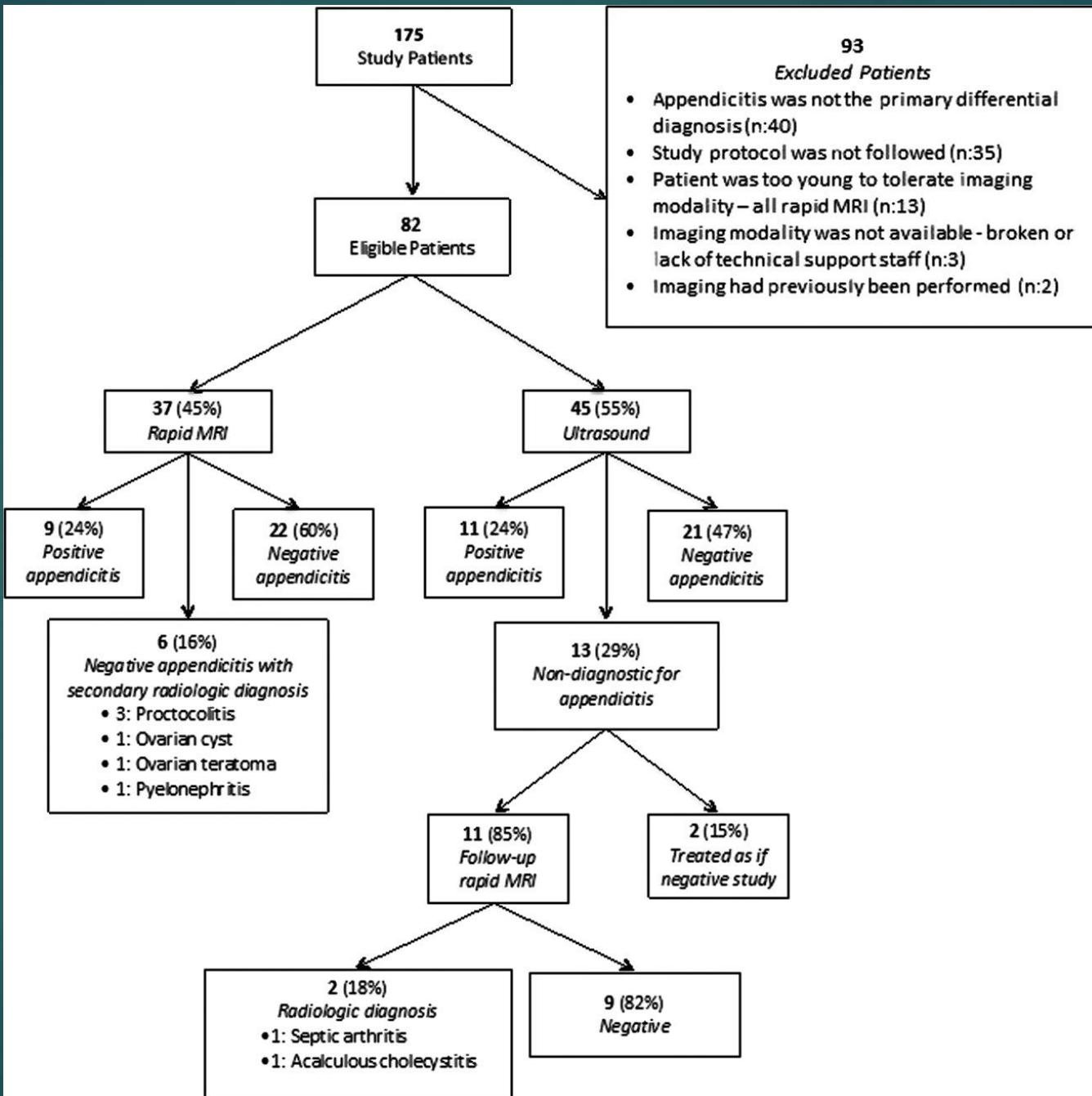
Material and Methods

- ▶ Imaging modalities: Initial rapid MRI vs. US with rapid MRI if needed
- ▶ If the physician decided to obtain radiologic imaging, the predetermined imaging modality for the day of the week was used.
- ▶ Time intervals (minutes) between triage, order placement, start of imaging, end of imaging, image result, and disposition (discharge vs. admission), as well as total charges (diagnostic testing, imaging, and repeat ED visits) were recorded.



Results

- ▶ Over a 100-day period, 82 patients were imaged to evaluate for appendicitis;
- ▶ 45 of 82 (55%) of patients were in the US-first group (median age 12.3)
- ▶ 37 of 82 (45%) patients were in the rapid MRI-first group (median age 13.5)
- ▶ 11 of 45 (24%) of US-first patients had inconclusive studies, resulting in follow-up rapid MRI and five return ED visits contrasted with no inconclusive studies or return visits ($p < 0.05$) in the rapid MRI group.
- ▶ **The rapid MRI compared to US group was associated with longer ED length of stay (mean difference = 100 minutes; 95% confidence interval [CI] = 35–169 minutes) and increased ED charges (mean difference = \$4,887; 95% CI = \$1,821–\$8,513).**



Discussion

- ▶ Rapid MRI
 - ▶ Increased cost
 - ▶ Charged as a full MRI A/P
 - ▶ Similar in cost to CT A/P
 - ▶ US group had more return visits, though was not significant compared to increased cost of MRIs
 - ▶ Longer wait times between when imaging is ordered and when it is performed
 - ▶ Due to time spent in MRI patient screening, patient transport, and in wait for MRI availability

Discussion continued

- ▶ Ultrasound continues to be gold standard first line imaging for suspected pediatric appendicitis
- ▶ Consider issues with US (body habitus) on deciding when to move straight to rapid MRI or CT
- ▶ Rapid MRI has potential to rival ultrasound if availability and cost come down in the future
 - ▶ Given increased access and specificity/sensitivity nearing 100%
 - ▶ Remaining barriers include MRI screening time and patient transport

Study Limitations

- ▶ Time, resource availability, and differences in charges vary institutionally and therefore can't be generalized
- ▶ Disproportionate female representation in study (66% in US, 70% in MRI) which may be due to provider bias
- ▶ POC ultrasound was not included as a modality in the study
- ▶ Cost effectiveness of incidental MRI findings was unable to be included in the study.

Module Outline

- ▶ I. Case
- ▶ II. Background
- ▶ III. Article Overview
- ▶ IV. **Clinical Questions**
- ▶ V. Key Points

Clinical Questions

- ▶ When is H&P enough to proceed without imaging?
- ▶ When should ultrasound be used to evaluate suspected pediatric appendicitis?
- ▶ What factors might lead you to pursue further imaging?
- ▶ How do you decide whether to incorporate these findings into your own clinical practice?

Module Outline

- ▶ I. Case
- ▶ II. Background
- ▶ III. Article Overview
- ▶ IV. Clinical Questions
- ▶ V. **Key Points**

Key Points

- ▶ Appendicitis should always be on the differential in rapidly increasing pediatric abdominal pain
- ▶ Ultrasound is your friend; don't hesitate to use it as an additional diagnostic tool!
- ▶ If ultrasound is negative, reconsider patient's clinical picture before proceeding with more imaging

References

1. Gadiparthi, Rekha. "Pediatric Appendicitis." *StatPearls [Internet]*., U.S. National Library of Medicine, 16 Dec. 2019, www.ncbi.nlm.nih.gov/books/NBK441864/#:~:text=development%20of%20peritonitis.-,History%20and%20Physical,after%20the%20onset%20of%20pain.
2. Sargar, Kiran M, and Marilyn J Siegel. "Sonography of Acute Appendicitis and Its Mimics in Children." *The Indian Journal of Radiology & Imaging*, Medknow Publications & Media Pvt Ltd, Apr. 2014, www.ncbi.nlm.nih.gov/pmc/articles/PMC4094970/.
3. Reich JD et al. "Use of CT Scan in the Diagnosis of Pediatric Acute Appendicitis." *Pediatric Emergency Care*, U.S. National Library of Medicine, 2000, pubmed.ncbi.nlm.nih.gov/10966341/.
4. Antonia E Stephen et al. "The Diagnosis of Acute Appendicitis in a Pediatric Population: To CT or Not to CT." *Journal of Pediatric Surgery*, U.S. National Library of Medicine, 2003, pubmed.ncbi.nlm.nih.gov/12632351/.
5. Imler, Daniel, et al. "Magnetic Resonance Imaging Versus Ultrasound as the Initial Imaging Modality for Pediatric and Young Adult Patients With Suspected Appendicitis." AAEM, 24 Apr. 2017