A Quality Improvement Initiative to Decrease Radiation Exposure in Pediatric Patients Suspected to Have Acute Appendicitis

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Introduction

- Abdominal pain concerning for acute appendicitis is one of the leading reasons children present to the emergency department

- Although CT is the gold standard for evaluating the appendix, radiation exposure raises significant concern

- Tissues of pediatric patients are more sensitive to radiation when compared to adults

- Children also have a longer life expectancy and therefore, a greater potential latent period of the cancer causing effects of radiation
Patient Safety and Radiation Exposure

- In 2014 the ECRI (Emergency Care Research Institute) identified CT radiation exposures in pediatric patients as a Top 10 Health Technology Hazard\(^1\)
- Patient Safety Council at Winthrop University Hospital has identified reducing radiation exposure in pediatric patients as a quality improvement project
- We identified CT scans of the abdomen and pelvis for a concern of appendicitis as a significant source of radiation exposure in children
- We formed a multidisciplinary team to conduct a failure-mode-effect-analysis (FMEA)

Gap Analysis

- Retrospective analysis of baseline data at our institution from June-August 2014 showed that 79% of pediatric patients ages 4-18 years have received a CT scan of the abdomen and pelvis as part of the diagnostic imaging work-up for a concern of appendicitis
- Literature review showed a utilization pattern of CT scans closer to 45% at children’s hospitals\(^2\)
- Further gap analysis identified suboptimal accuracy of abdominal US in rendering a diagnosis of appendicitis or identifying a normal appendix in our institution as a limiting factor
Goal

Decrease the percentage of pediatric patients receiving abdominal and pelvis CT examination at our institution for suspected appendicitis by 30% over the course of one year.

Methods

• Formed a multidisciplinary team of pediatric emergency room physicians, radiologists, sonographers and pediatric surgeons.

• Pediatric emergency room physicians and surgeons ordered ultrasounds as the first line diagnostic study and triaged patients based on PAS (Pediatric Appendicitis Score)³.

• The radiology department implemented a multistep approach to improve the accuracy of right lower quadrant ultrasounds.

• Provided education to community clinicians to avoid referrals to the emergency room for CT scans for concern of appendicitis.
Steps to Improving US Accuracy

- Identified barriers to visualizing the appendix
- Developed a scanning protocol to mitigate these challenges
- Provided didactic lectures reviewing anatomy and scanning techniques for ultrasound technologists
- Provided hands-on training sessions for sonographers and radiologists by an expert from an outside institution, utilizing healthy volunteers to aid in identifying a normal appendix
- Mandated the presence of a radiologist for every ultrasound for a concern of appendicitis
- Pediatric credentialed, as well as more experienced sonographers, worked with all sonographers to increase their proficiency

Challenges to Visualizing the Appendix

- Variable location of appendix
- Difficult locations to image (retrocecal and deep pelvic)
- Patient body habitus
- Patient cooperation
- Sonographer proficiency in appendiceal ultrasonography
SCANNING PROTOCOL

- 9-14MHz linear transducer is placed in the right upper quadrant to locate the ascending colon, as well as to potentially identify a high riding appendix.
- The ascending colon is followed inferiorly to identify the cecum and the terminal ileum using graded compression technique to displace bowel gas.
- The appendix is frequently identified posterior and inferior to the terminal ileum.

If the appendix is not identified using the above technique, other potential location for appendix are explored:
- Retrocecal
- Periumbilical
- Deep pelvic
- After the appendix is identified, static and cine clips from the base to the tip are obtained.
- The maximum anterior-posterior measurement of the appendix is taken.
- Color Doppler images are obtained to evaluate for hyperemia.
- If present, images of appendicolith, inflammatory changes, and collections are obtained.
Ultrasound Interpretation

- Ultrasounds are interpreted as normal, abnormal, or equivocal
- Normal appendix: entire appendix visualized, 6 mm or less in diameter, no secondary changes of appendicitis
- Abnormal appendix: dilated, hyperemic appendix greater than 6 mm in diameter with surrounding inflammatory changes
  - Additional findings may include appendicolith and/or collections
- Equivocal:
  - Appendix not visualized
  - Partially visualized-tip not fully imaged
  - Completely visualized but equivocal in appearance, for example mildly dilated without inflammatory changes

Normal caliber appendix demonstrating normal architecture and no surrounding inflammation
Dilated, fluid filled appendix with surrounding echogenic inflammatory changes, consistent with acute appendicitis

Dilated appendix located between the liver and the kidney
Dilated appendix with hyperemia and peri-appendiceal inflammation

Perforated appendix with surrounding inflammatory changes. Target-like mass mimics the appearance of intussusception. A similar phenomena was previously reported. 4,5
The terminal ileum (TI) is seen anterior to the appendix with surrounding inflammatory changes (*). The appendix contains a shadowing appendicolith (A), which demonstrates posterior shadowing.

Clinical Management

- Patients with normal ultrasound and benign physical exam were discharged
- Patients with ultrasound consistent with appendicitis underwent appendectomy
- Patients with equivocal ultrasound were triaged based on PAS score.
  - High clinical suspicion for appendicitis: CT abdomen and pelvis
  - Low clinical suspicion for appendicitis: Discharge with close outpatient follow up
  - Intermediate clinical suspicion for appendicitis: Admit for observation, serial abdominal exams and CBC with possible repeat US. CT abdomen and pelvis if symptoms persist or worsen. Discharge if symptoms resolve
Timeline

• February 2015 - Formed a multidisciplinary team to decrease radiation exposure from CT scans in pediatric patients for concern of appendicitis
• March 2015 - Began logging all ultrasound cases performed for evaluation of the appendix
• April 2015 - Provided didactic lectures reviewing anatomy and scanning techniques for ultrasound technologists
• June 2015 - Completed hands on training sessions for sonographers and radiologists by an expert from an outside institution, utilizing healthy volunteers to aid in identifying a normal appendix

Data Collection

• To monitor progress, every case of ultrasound performed for a concern of appendicitis was logged beginning March 2015
• Ultrasound and CT scans for evaluation of appendix were logged retrospectively from June to August 2014 to compare to June (completion of training) - August 2015
• Results of ultrasounds were recorded as normal, abnormal or equivocal
• Subsequent CT scans, operative, and pathology reports were also recorded
Results

- A total of 55 ultrasounds were performed from June-August 2014 for evaluation of appendicitis
  - 11 rendered diagnosis of appendicitis or normal appendix (20%)

- A total of 188 ultrasounds were performed from March-August 2015 for evaluation of appendicitis
  - 59 rendered diagnosis (31%)

- 102 ultrasounds were performed from June-August 2015, after implementation of our multistep approach
  - 47 rendered diagnosis (46%)

Results

- A total of 102 CT examinations were performed from June-August 2014 for evaluation of appendicitis

- A total of 48 CT examinations were performed from June-August 2015 for evaluation of appendicitis
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**2015 Appendix Visualized & Diagnosis Rendered Using Ultrasound**

- March: 0% (n=17)
- April: 16% (n=31)
- May: 18% (n=38)
- June: 39% (n=36)
- July: 49% (n=35)
- August: 52% (n=31)

**Hands on Training**

March: 0%
April: 10%
May: 20%
June: 30%
July: 40%
August: 50%

**Data Log**

Started Didactic Training

- n= number of ultrasounds performed

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**Appendix Visualized & Diagnosis Rendered using Ultrasound Winthrop’s Data compared to Cincinnati Childrens Hospital**

- June-August 2014: 20%
- June-August 2015: 46%
- Cincinnati Childrens Hospital: 47%
% of Patients Exposed to CT for concern of appendicitis

- June - August 2014: 82%
- June - August 2015: 41%

Patients imaged with CT vs. US

- June - August 2014:
  - Total CTs: 102
  - Total US: 55
- June - August 2015:
  - Total CTs: 102
  - Total US: 48
Conclusion

- We identified CT of the abdomen and pelvis for concern of appendicitis as a significant source of radiation exposure in pediatric patients at our institution
- Multidisciplinary team was organized to conduct a failure-mode-effect analysis (FMEA)
- Suboptimal accuracy of ultrasound at our institution was identified as a contributing factor to overuse of CT examinations
- Multistep approach was implemented to improve accuracy of ultrasound
- Referring physicians were encouraged to order right lower quadrant ultrasound as a first line study
- Patients with equivocal ultrasound and intermediate clinical concern were observed. CT was obtained only if symptoms did not improve

Conclusion

- Comparing summer 2014 to summer 2015, the percentage of patients imaged with CT decreased by 50%, surpassing our initial goal of a 30% reduction
- Ultrasound utilization increased by 46%
- As our initiative progresses, we hope to achieve further improvement in ultrasound accuracy thereby resulting in reduction of utilization of CT diagnose appendicitis
References


2. Larson DB, et al. Improvement in Diagnostic Accuracy of Ultrasound of the Pediatric Appendix Through the Use of Equivocal Interpretive Categories. AJR Am J Roentgenol. 2015;204;849-856


