



## 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<sup>1</sup>
- 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<sup>2</sup>
- Further gap analysis identified suboptimal accuracy of abdominal US in rendering a diagnoses 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)<sup>3</sup>.
- 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

## SCANNING PROTOCOL

- 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.

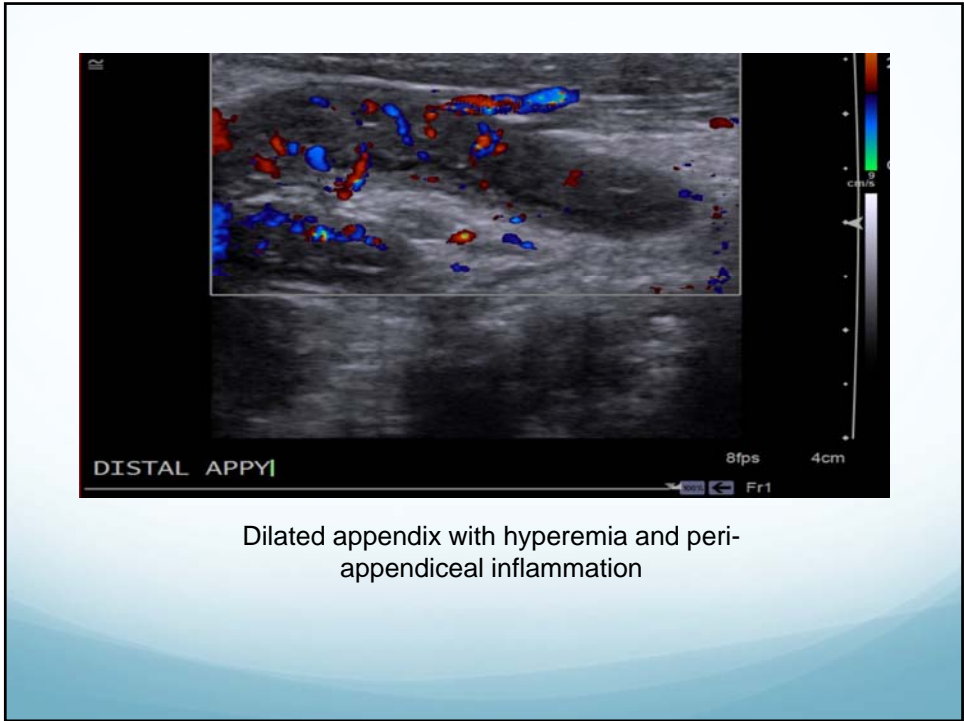
## Ultrasound Interpretation

- 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

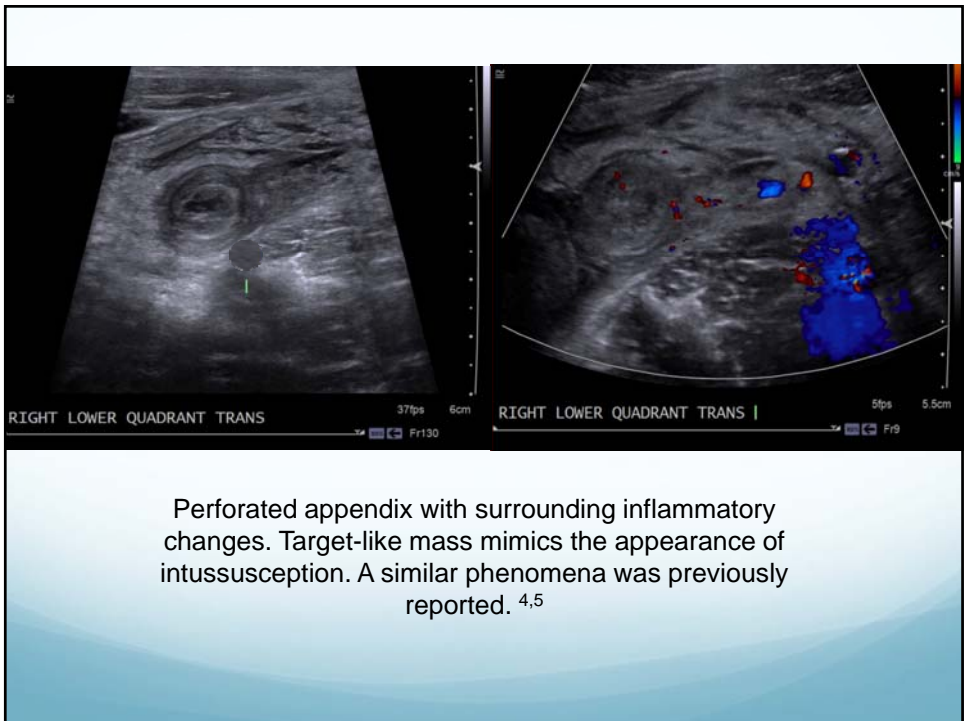


Normal caliber appendix demonstrating normal architecture and no surrounding inflammation



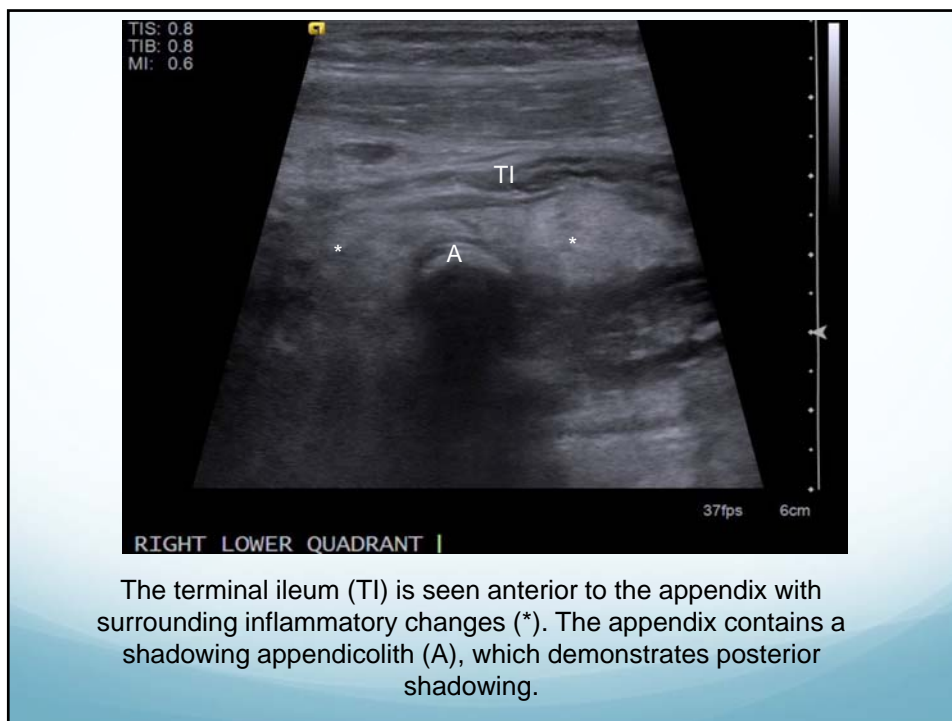


Dilated appendix with hyperemia and peri-appendiceal inflammation



Perforated appendix with surrounding inflammatory changes. Target-like mass mimics the appearance of intussusception. A similar phenomena was previously reported. <sup>4,5</sup>





## 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

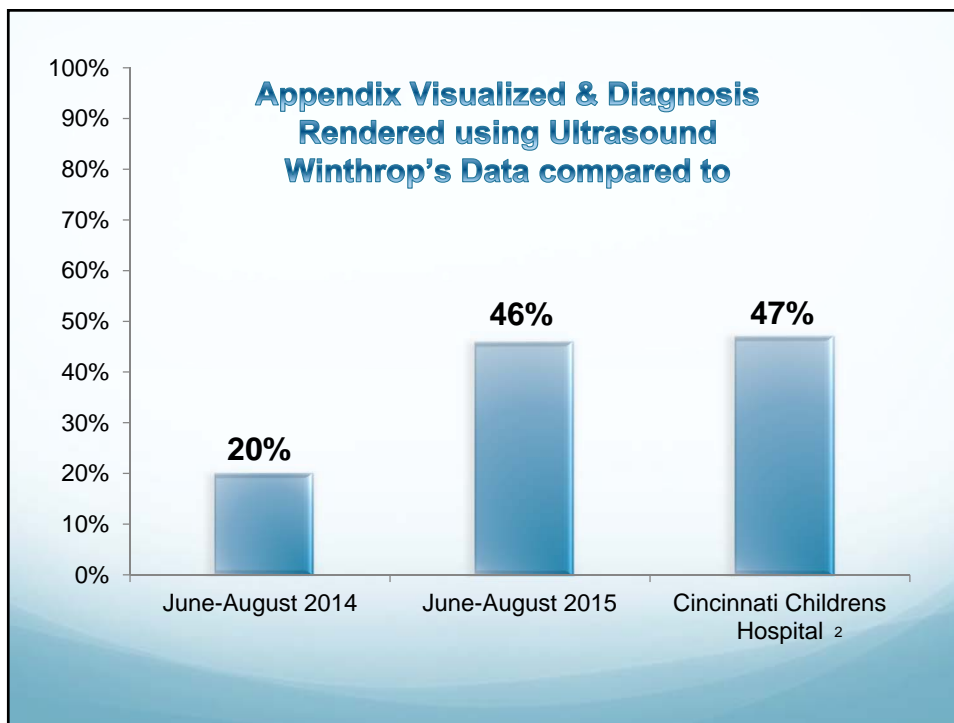
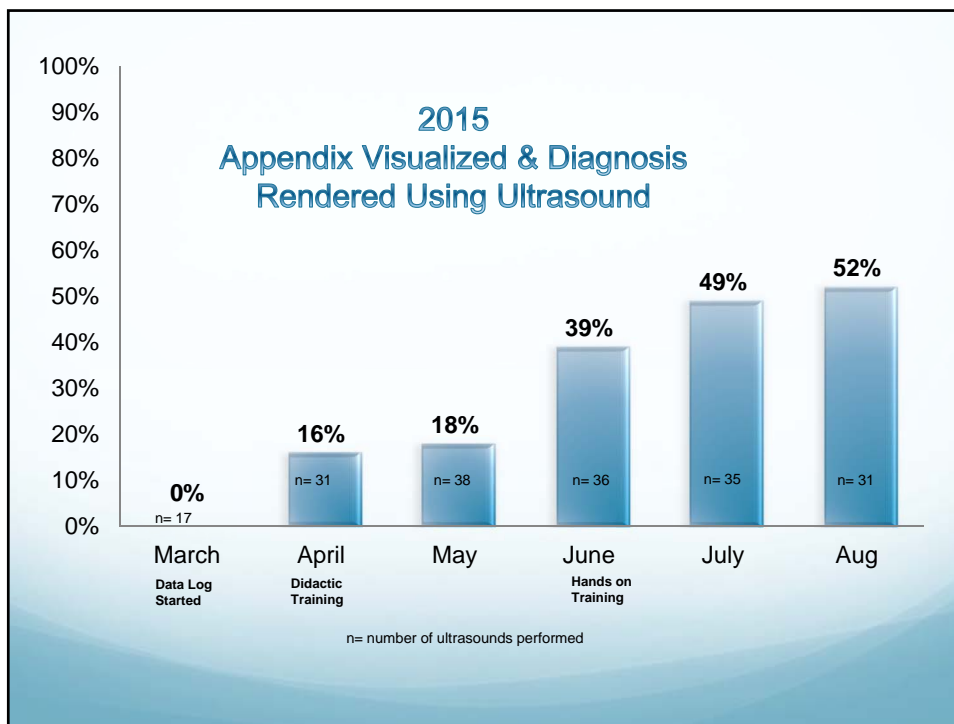
- To monitor progress, every case of ultrasound performed for a concern of appendicitis was logged beginning March 2015
- Ultrasound and CT scans for evaluation of appendix were logged retrospectively from June to August 2014 to compare to June (completion of training) - August 2015
- Results of ultrasounds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

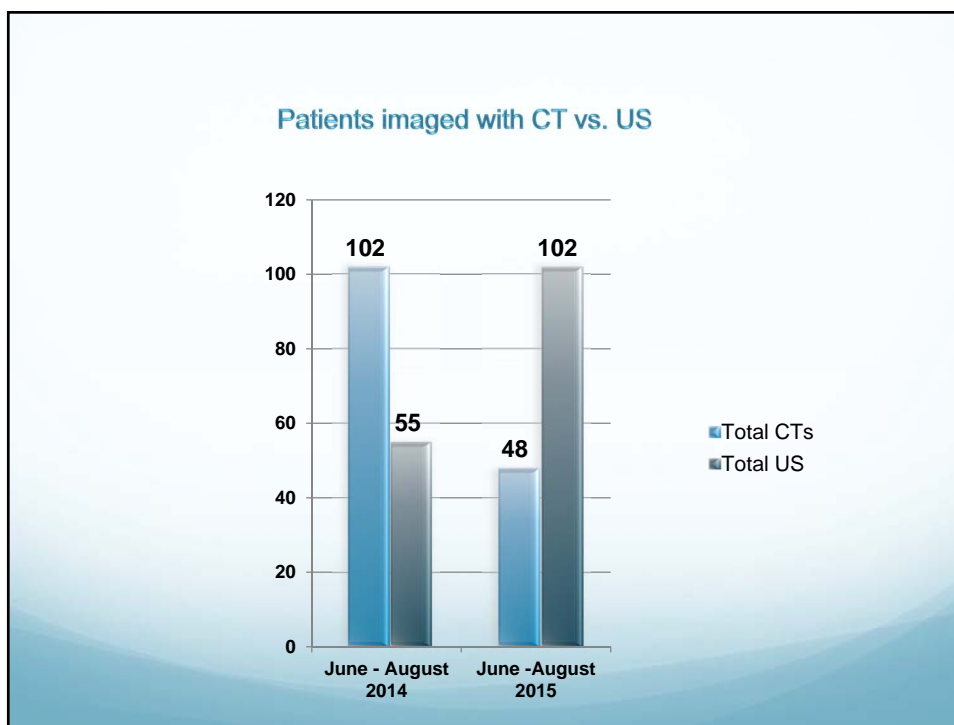
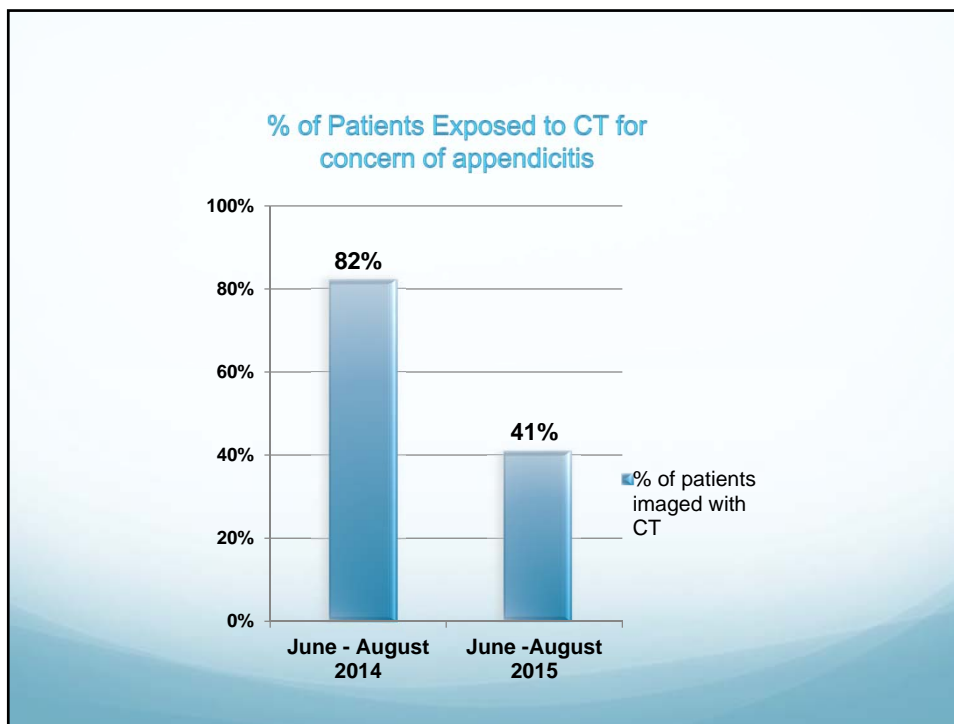
## Results

- 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





## 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

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