



## Approaching zero: Implications of a computed tomography reduction program for pediatric appendicitis evaluation<sup>☆</sup>



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### ARTICLE INFO

#### Article history:

Received 2 August 2017

Accepted 28 August 2017

#### Key words:

CT

Computed tomography

Pediatric appendicitis

MRI

Magnetic resonance imaging

ALARA

### ABSTRACT

**Purpose:** Because of awareness of iatrogenic radiation exposure, there is a national trend of diminishing computed tomography (CT) use for pediatric suspected appendicitis. The purpose of this study was to evaluate the effects of a CT reduction program for evaluation of appendicitis.

**Methods:** A multidisciplinary group (emergency medicine, radiology, and surgery) at a children's hospital developed a reduction program which included: ultrasound (U/S) first (2012), magnetic resonance imaging (MRI) second (2014), and standardized U/S reports (2016). Imaging modality, negative appendectomy rate, time from first image to incision, and imaging costs were evaluated over time.

**Results:** Of the 571 patients evaluated from 2012 to 2016, there was a significant decrease in CT use and increase U/S and MRI use over the study period (all  $p < 0.01$ ). CT use approached zero in 2016. Time from first image to incision (median 10.7 h, IQR 5.6–15.5) and negative appendectomy rate (mean  $3.7 \pm 0.2\%$ ) did not change. Median imaging costs (\$88, IQR \$52–\$169) and radiology percent of total costs (range 0.8%–3.9%) increased over time (both  $p < 0.01$ ).

**Conclusion:** Approaching zero CT use for evaluation of pediatric appendicitis is possible through a multidisciplinary protocol without impacting clinical outcomes. However, increased MRI use led to higher costs. Cost-effectiveness of replacing CT with MRI warrants further study.

**Type of study:** Retrospective comparative study.

**Level of evidence:** Level III.

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Appendicitis, the most common urgent pediatric surgical condition, is typically diagnosed based on imaging in addition to clinical presentation. There is a national trend of decreasing computed tomography (CT) use for the evaluation of suspected appendicitis in children because of the increased awareness of iatrogenic radiation exposure [1]. Many children's hospitals evaluate fewer than 25% of patients with CT for suspected appendicitis [2]. These low rates of CT use are often achieved with clinical practice guidelines or protocols [3–5].

The impact of decreased rates of CT use is not clear. Though avoiding CT is preferable in order to reduce the potential for future cancers, there are concerns with eliminating its use completely. CT is generally acknowledged as slightly better in sensitivity and specificity than ultrasound (U/S), though this difference is less in the pediatric population

[6]. There is apprehension that relying on U/S may lead to more negative appendectomies or missed appendicitis. To increase diagnostic certainty, magnetic resonance imaging (MRI) may be utilized instead of CT. However, increased use of MRI may lead to increased costs or longer times for evaluation [7–10].

A program to reduce CT use for suspected appendicitis was introduced in 2012 at our institution. The purpose of this study is to evaluate the impact of the CT reduction program on imaging trends and the effect of changing imaging practice patterns on the negative appendectomy rate, time from imaging to operating room and radiology costs.

### 1. Methods

#### 1.1. Study setting

Records of pediatric appendectomy patients who presented to Children's Memorial Hermann Hospital (CMHH), a tertiary academic medical center, from January 2012 to December 2016 were reviewed. CMHH is a 240-bed children's hospital, integrated into its adult

<sup>☆</sup> Financial Disclosures: None.

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counterpart in the Texas Medical Center, in Houston, Texas. CMHH is the pediatric specialty center for the Memorial Hermann Hospital System (MHHS). During the study period, there were 8 MHHS non-children's hospitals that evaluated and referred pediatric patients with suspected appendicitis. Over 40 free-standing or non-MHHS affiliated emergency departments (ED) also referred patients to CMHH during the study. Patients were included if they presented initially to CMHH or presented as a transfer without imaging.

### 1.2. CT reduction program

A dose reduction protocol for all pediatric CTs had previously been implemented [11,12]. In order to reduce CT use, a quality improvement project was initiated by physicians from the emergency, radiology and surgery departments at CMHH. Champions were identified in all departments and met to discuss facilitators and barriers to limiting CT use. Through consensus, a protocol for imaging choice was developed. Periodic interdepartmental meetings allowed for audit and feedback of imaging patterns. In 2012, the U/S first protocol was implemented in the emergency department. Previously, there were no guidelines on imaging strategy or when to call for surgical consult. With the protocol, ED staff call for surgical consult after U/S but before further imaging. The initial surgical consultant, typically a junior surgical resident, evaluates the patient and discusses with the pediatric surgery fellow or attending prior to secondary imaging or admission. The protocol was distributed to ED physicians and residents as well as published in the pediatric surgery team handbook.

From 2014, the protocol was modified to substitute fast MRI as the secondary imaging modality, in lieu of CT, when additional imaging was indicated because of an equivocal U/S and history. A fast MRI

consists of limited sequences to shorten the imaging time. The updated protocol was implemented in the same fashion as the U/S first pathway. In January 2016, the pediatric radiology department instituted standardized reporting templates for pediatric ultrasounds. The template includes prompts to specify primary and secondary signs of appendicitis in order to improve diagnostic accuracy (Fig. 1).

### 1.3. Study design

A retrospective cohort study of patients <18 years undergoing appendectomy for acute appendicitis from January 2012 to December 2016 was performed. Institutional review board approval was obtained for this study (HSC-MS-15-0330). Patients were identified as having undergone appendectomy by searching for International Classification of Diseases (ICD), 9th Revision, Clinical Modification (ICD 9-CM) procedure codes for appendectomy (47.0, 47.01, 47.09, 47.1, 47.11, 47.19, 47.2) or ICD, 10th Revision (ICD 10-CM) codes (OBDJ0ZX, OBDJ0ZZ, OBDJ3ZX, OBDJ3ZZ, OBDJ4ZX, OBDJ4ZZ, OBDJ7ZX, OBDJ7ZZ, OBDJ8ZX, OBDJ8ZZ, ODTJ0ZZ, ODTJ4ZZ, ODTJ7ZZ, ODTJ8ZZ). Appendectomy for appendicitis, not as part of another procedure, was confirmed by excluding those without the ICD 9-CM or ICD 10-CM discharge diagnosis of appendicitis (540, 540.0, 540.1, 540.9, 541; K35, K35.2, K35.3, K35.8, K35.80, K35.89, K36, K37). Children undergoing interval appendectomy were excluded. Patients were also excluded if imaging was performed prior to arrival at CMHH (Fig. 2).

### 1.4. Data collection and outcome measures

Electronic medical records were abstracted for patient demographics, imaging location, diagnostic modality employed (U/S, CT or

## Right Lower Quadrant US for Appendicitis Protocol – Children's Memorial Hermann Hospital

### FINDINGS:

The appendix [is/is not] seen.

### Visible appendix features:

Appendiceal diameter:

Appendicolith:

Vascularity of appendix:

Tenderness with compression:

Compressibility:

### Secondary findings:

Edematous right lower quadrant/periappendiceal fat:

Fluid collection: free fluid/loculated fluid

Clustered lymph nodes:

### IMPRESSION:

[The appendix is seen and appears normal.]

[The appendix is seen and has features of acute appendicitis.]

[The appendix is not seen, but no secondary findings of appendicitis are present.]

[The appendix is not seen, but secondary findings are present that might indicate appendicitis. CT or MRI may be worthwhile.]

Fig. 1. Ultrasound reporting template introduced in January 2016.

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